Feeding the Dairy Cow Efficiently

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Feeding the Dairy Cow Efficiently

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Dairy farming predominates in New York agriculture because many farms can best grow roughage crops. If farmers are to remain on these farms and make a living, they must keep livestock and convert their roughage crops into a concentrated and salable product because there is no satisfactory cash market for these crops. Dairy cows use these roughage crops efficiently in the production of milk. Also, milk is an indispensable human food that can be readily disposed of for cash through nearby Metropolitan markets.

Economy in milk and butterfat production, therefore, is concerned not alone with feeding enough of the right kinds of nutrients to get full production from good cows, but also with feeding as many as possible of those nutrients in home-grown feeds. To be most successful, a dairyman must therefore make the fullest use of the natural resources of his soil in the production of large yields of high-quality feed crops. The efficiency and capacity of the cows used in making milk and butterfat from farm-grown feeds play an important part in determining the returns received for those feeds.

High-Producing Cows Essential to Successful Dairy Farming

Production Related to Income over Feed Cost

Only cows of high producing ability can be profitably kept on New York farms unless much-better-than-average markets are available.

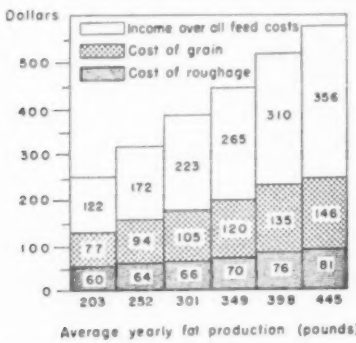

Figure 1. Relation of butterfat production to income over feed costs. The higher producing cows returned the largest incomes over feed costs. This information is from 54,810 records in New York dairy-herd-improvement associations in 1947–48.

Results from seven groups of dairy-herd-improvement-association cows, varying in production by about 50 pounds of butterfat a cow annually, show that although there is little increase in the cost of the roughage in rations fed to higher producing cows there is some increase in the cost of grain (figure 1). The value of the extra milk and butterfat produced is so much greater, however, that the incomes over feed costs are profitable. An average of $13.80 was added to the cost of grain for each increase of 50 pounds of butterfat produced by the groups of cows studied but the average increase in value of product was $64.80, or an average increase in income over all feed costs of $46.80 for each 50-pound increase in yearly butterfat production.

High-producing Cows a Good Market for Home-grown Roughage

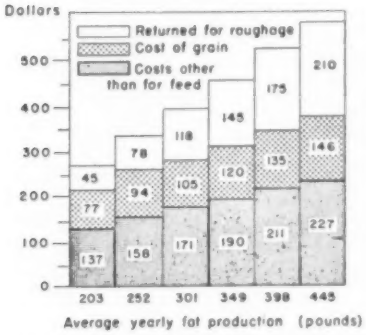

Figure 2. Relation of butterfat production to returns from roughages fed. The higher producing cows are a good market for home-grown roughages. This information is from 54,810 records in New York dairy-herd-improvement associations in 1947–48.

To show the relation between good cows and the returns for hay, silage, and pasture eaten, another study was made of these same groups of cows. The estimated total cost of production, other than for feed and the cost of grain, was deducted from the total average value of the milk produced by each cow. The amount remaining was the average return made for roughage. For this study, feed costs were considered to be one-half of the total cost of milk production. The average price paid per 100 pounds of milk during the period covered was $4.79.

The results of this study (figure 2) show that only $45 was left to pay for hay, silage, and pasture in the 203-pound-butterfat group of cows. With each increase of 50 pounds in butterfat production, there was an average increase of $33 in the amount left to pay for roughage feeds. For the 445-pound-butterfat group, $210 was left to pay for hay, silage, and pasture. It is, therefore, just as important to consider the market (the cows) for roughages as it is the market for milk.

High Quality in Home-grown Roughages

Feed nutrients in New York normally cost less in home-grown roughages than they do in either home-grown grain or in purchased grain mixtures. This is particularly true of good pastures. The digestive system of the cow is well adapted to the consumption of large amounts of roughage, and it is best to furnish as large a part of the total nutrients required by cows in home-grown roughages as is practical. Under normal milk-market conditions, the number of cattle kept on a farm should be adjusted to the supply of home-grown roughage that can be produced on the farm. It is poor business to feed hay, silage, and pasture to poor cows when a reduction in the size of the herd by culling would permit heavier feeding of roughage to cows that are capable of making greater returns for the feeds they eat.

Size of business and efficient production of crops and milk determine the financial returns on dairy farms. With an increase in yields of crops per acre, it may be possible for a farm to carry more cattle without any increase in acreage and also to reduce the cost of nutrients in home-grown feeds. Increasing the production of milk and butterfat per cow increases the volume of business and reduces the cost of milk and butterfat production.

How the Cow Uses Feed

The dairy cow is unsurpassed in the efficiency with which she converts forage crops into human food in the form of milk.

To feed cows profitably, dairymen need to know how the animal uses her feed. The dairy cow needs food for (1) maintenance and (2) for production.

She needs feed to keep all her vital organs functioning properly, to replace worn-out body tissues, to maintain body temperature, and to provide energy for muscular activity. The larger the cow, the greater are her maintenance needs. For average dairy cows, these needs amount to about one-half of the total feed-nutrient requirements.

The requirements for production are for growth, for development of the fetus, and for milk production. The amount of feed required by a cow over her needs for maintenance depends upon the amount of milk produced and upon the composition (or quality) of the milk. Milk that is rich in fat is also higher in protein and may be higher in sugar than is milk lower in butterfat. Therefore, cows producing high-fat milk require more feed nutrients for each pound of milk produced than do those producing a lower fat milk.

Generally, young, immature cows (from 2 to 5 years of age) should be fed above their actual requirements for maintenance and milk production to enable them to reach their maximum inherited size. Also, cows need extra feed toward the end of pregnancy to provide for the developing calf. This requirement, however, is relatively low.

Functions of Feed Nutrients

Feeds contain many nutrients that are grouped as: water, mineral matter or ash, vitamins, protein, fat, and carbohydrates. Fundamentally, feeds, the animal body, and milk are composed of these groups of compounds in varying amounts.

Water plays an important part in the body processes. It forms a part of all the body tissues and fluids, and large amounts are needed in the digestive processes. Water helps to carry food nutrients to various parts of the body, to control the temperature of the body, and to remove waste products. Also, water composes about 87 per cent of the constituents in milk.

Minerals are essential for the growth and maintenance of the skeleton and for the proper functioning of all the body processes. Milk is rich in certain minerals, particularly calcium and phosphorus; therefore, the ration must furnish plenty of these needed minerals.

While **vitamins** are needed in relatively small amounts, certain ones are essential for growth and for the maintenance of health. Normal reproduction and proper use of minerals are dependent upon an adequate supply of vitamins.

Growth of the animal body is largely dependent upon **protein.** This nutrient is also necessary for maintenance of the tissues and the development of the fetus. Milk is rich in protein; therefore, high-producing cows need much of this nutrient for their functions.

Fat is important in the ration as a source of energy. In addition, fats have a nutrient value in excess of their energy value alone. While fat may be formed in the body from carbohydrates and proteins, milk fat may be produced most efficiently from fat in the ration rather than from carbohydrates or proteins.

Carbohydrates consist of crude fiber and nitrogen-free extract. They appear in the largest quantities in feeds in the form of starches, sugars, and crude fiber and provide the chief source of energy for body functions. This energy is used largely to maintain body heat, for activity, and for milk production.

Process of Digestion

Cattle eat and utilize large amounts of roughage because of the great capacity of their stomachs and because the fiber is digested in the stomach. Cows have a compound stomach, with four compartments, which in a mature cow may hold more than 60 gallons of material.

Cows crush and chew their feed enough to moisten it thoroughly with the saliva, then swallow it. The feed goes into the rumen, or paunch. The paunch comprises about 80 per cent of the volume of the complete stomach, while the fourth compartment, or so-called true stomach, makes up only about 8 per cent of the volume. The paunch acts as a reservoir. Here the masses of feed are mixed thoroughly and softened with the water and liquids in the paunch. The action of certain bacteria in the paunch is essential in the digestion of fiber and cellulose materials that make up such a large proportion of roughages. It is because of this bacterial action that cows can live chiefly on roughage.

Cud chewing helps digestion by reducing the size of the feed particles and by preparing them for digestive action. After the cud has been thoroughly chewed, the finely chewed material is returned to the paunch and from there it passes on through the other compartments to the true stomach. Kernels of heavy grains may escape this second chewing and pass through undigested unless they become entangled in coarse masses of forage; hence, the saving of grain feeds through grinding.

It is in the fourth compartment, or abomasum, that most of the stomach digestion takes place. Certain digestive juices act on the proteins, rendering them into a simpler state. The carbohydrates and fats are only slightly digested until the food reaches the small intestine. Digestive juices break down the different food nutrients into simple compounds so they can be absorbed through the wall of the intestines into the blood stream. The nutrients are then carried by the blood to all parts of the body to perform their various functions in maintaining the body, supplying the organs with energy, and furnishing the ingredients for the manufacture of milk.

Digestibility of Feeds

As the feed passes through the cow, only certain portions of the protein, fat, and carbohydrates are digested, absorbed, and utilized by the animal. The undigested portions pass through the digestive tract and are of no value to the animal. By using the percentage of digestibility of the different nutrients, the proportion of digestible protein, digestible fat, and digestible carbohydrates can be calculated. The total-digestible-nutrient (T.D.N.) content of a feed is equal to the sum of the digestible protein plus the digestible carbohydrates, plus the digestible fat (which is multiplied by 2.25). The amount of fat is increased because when it is used inside the animal body, it furnishes two and one-fourth times as much heat or energy as does a pound of protein or carbohydrate.

The percentage of total digestible nutrients represents the approximate heat or energy value of a feed, and can, therefore, be considered as an approximate measure of the feeding value of the various feeds. The average composition and total digestible nutrient content of the more common feeds are given in table 7 (pages 45 and 46).

In addition to the total digestible nutrients, other nutritional requirements must be considered in efficient feeding; such as, the amounts of digestible protein, the mineral and vitamin contents, and the suitability of feeds for dairy cows.

Feeds vary in digestibility, depending largely upon their fiber content. Feeds high in fiber, such as roughages, are generally low in digestibility. In contrast, concentrate feeds, such as corn and barley, are low in fiber and high in digestible nutrients. A mixture of grains and by-product feeds usually contain about 70 to 75 per cent total digestible nutrients, or from 1400 to 1500 pounds to the ton. Good hay furnishes about two-thirds as much total digestible nutrients as a concentrate mixture, or about 50 per cent. Hay that is late-cut and stemmy is higher in fiber and considerably lower than 50 per cent in digestibility.

Fortunately, the digestive system of the cow is capacious and well developed for the use of bulky roughages containing liberal amounts of fibrous material.

Requirements of a Dairy Ration

For efficient and economical production, cows must have enough: (1) total digestible nutrients; (2) protein; (3) fat; (4) the essential minerals, particularly common salt, calcium, and phosphorus; (5) the necessary vitamins, especially carotene and vitamin D, and (6) fresh water at all times. Furthermore, these materials must be provided in a ration that is palatable to the cows.

Total Digestible Nutrients

The cow with an inheritance for large quantities of milk and butterfat must be fed up to her capacity to eat and use feed. More cows suffer from underfeeding than from any other single nutritive deficiency.

The amounts of feeds needed by cows are discussed on pages 33 to 36 and the requirements for total digestible nutrients are given in table 8 (page 47).

Protein

Protein is given much consideration in formulating rations for dairy cows because milk is rich in this nutrient and because growth and other body processes are dependent upon protein.

Many studies have been made to determine the most satisfactory amounts of protein for dairy cows, because high-protein feeds often cost more than do the lower-protein farm grains and by-product feeds. Also, the supply of high-protein feeds may be limited. Under usual conditions, therefore, it is wise to feed no more protein in the ration than is generally needed for efficient production.

The proportion of protein that is needed in the concentrate mixture depends largely upon the protein content of the roughage fed and to a lesser extent upon the amount of roughage eaten. The amounts of protein needed in concentrate mixtures for the various types of roughages are as follows:

Percentage of total protein	Roughage
12 to 14	Alfalfa or soybean hay and corn silage Excellent spring or fall pasture
14 to 16	Clover hay and corn silage Fair to good pasture
16 to 20	Mixed legume and non-legume hay and corn silage Poor pasture
20 to 24	Timothy hay or other non-legume forage and corn silage

If no silage is fed with alfalfa, clover, soybean, or other legume hay, the percentage of protein in the concentrate mixture may be slightly lower than indicated. If silage made from legumes or early-cut grasses is fed, the protein content of the concentrate mixture may be reduced somewhat, at least to the lower levels of the protein shown.

One of the most usual combination of roughages fed on dairy farms in New York is a mixture of clover, and other legumes, and timothy hay and corn silage. Extensive experiments were conducted a few years ago at Cornell University to determine how much protein is needed in the concentrate mixture with this combination of forages. The mixed hay used in these experiments contained at least 30 per cent of clover. The hay was cut fairly early and was of good quality. In the feeding trials, good dairy cows that yielded an average of 10,000 pounds of milk a year produced just as much milk on a 20-per-cent-protein mixture as they did on a 24-per-cent mixture. The cows fed a 16-per-cent-total-protein–grain mixture produced almost as much as they did on the 20- or 24-per-cent mixture. When a low-protein–grain mixture, containing only 12 per cent of protein, was fed, milk production was decidedly decreased; the average decrease was 12 per cent. On each of these rations the cows were fed approximately 1 pound of grain to each 3.4 pounds of milk produced.

It is evident that with mixed clover and timothy hay, the concentrate or grain mixture should furnish at least 16 per cent of protein, but there is no need for more than 20 per cent. When high-protein feeds are plentiful and not too expensive in relation to low-protein ingredients, it might be desirable to feed at the higher level of 20 per cent.

On those farms where good-quality, legume hay, especially alfalfa, is available, a concentrate mixture made up of farm grains will supply enough protein to meet the needs of dairy cows.

For some classes of animals, the kind or quality of protein may be fully as important as the amount. Experimental evidence indicates, however, that quality of protein in concentrate mixtures is not important in practical dairy feeding. Studies show that dairy cows are able to manufacture protein from non-protein-nitrogen substances, such as urea, through the action of bacteria in the paunch. These bacteria can use the urea to build up their bodies and then the cow digests the bacteria to get her protein. It is because of this bacterial action in dairy cows that experiments have not shown any differences in feeding value between high-quality and low-quality protein concentrate mixtures.

Fat

Dairy cows can manufacture fat in milk from other food nutrients than fat, such as carbohydrates and proteins, but experiments have shown that dairy cows can produce milk fat more readily from food fat than by making it from these other nutrients. Therefore, the ration for high-producing cows should furnish a minimum amount of fat; otherwise, the milk and fat yield may be lowered.

The most extensive experiments on this problem were conducted at Cornell University. In most of these feeding trials, comparisons were made of concentrate mixtures containing about 2 per cent of fat with those containing from 4 to 6 per cent. In a total of 18 different comparisons more milk was always produced with the higher fat mixtures. The average increase in milk yield amounted to 4 per cent. It has, therefore, been generally recommended that the concentrate mixture should contain about 4 per cent of fat.

Until recently it was no problem to formulate mixtures with 4 per cent or more of fat. There has, however, been a rapid increase in the use of solvent extraction in the production of oil-meal feeds, especially soybean oil meal, which removes most of the fat from the seeds and leaves oil meals with less than 1 per cent of fat. In contrast, soybean oil meal made by the hydraulic or expeller processes commonly contained from 4 to 5 per cent of fat. With this situation, it is more difficult for feed manufacturers and farmers to formulate mixtures containing 4 per cent of fat. Milk production can be satisfactory when concentrate mixtures contain as low as 2 or 3 per cent of fat. It is, therefore, largely a question of economy. If a higher level costs more to obtain than increased milk yields might offset, then economy might dictate the use of lower fat mixtures.

Minerals[1]

The animal body requires many mineral elements for its nutrition, without any one of which growth, production, and health will fail. Since essentially the same minerals are required for plant growth as are needed by animals, the normal feed of animals is not entirely lacking in these minerals. Also, enough of most of the minerals is furnished in the farm rations ordinarily fed. Certain of the minerals, however, are lacking under some feeding conditions and must be added to the ration.

Common salt

Sodium and chlorine, the two mineral elements of common salt, are the only minerals universally lacking from dairy rations. Both are essential for proper functioning of the animal body.

The salt requirements vary with the size of the cow, the type of the ration, and the amount of milk produced. Cows need 0.75 ounce of salt for each 1000 pounds liveweight plus 0.3 ounce for each 10 pounds of milk they produce. The best way to supply these needs is to allow free access to salt blocks or to loose salt placed in a box in the yard or pasture or in cups in the barn. It is also desirable to add 1 per cent of salt to the concentrate mixture.

Calcium and phosphorus

Calcium and phosphorus make up about three-fourths of the total mineral matter in the bodies of dairy animals and more than 50 per cent of that in milk. Therefore, liberal amounts are needed to build strong bones, for growth, and for milk production. In pregnancy the need for calcium and phosphorus is increased considerably.

To assimilate and use properly the calcium and phosphorus in their feed, dairy cattle must have enough vitamin D.

Under present-day conditions, dairy cows are more likely to suffer from a deficiency of calcium or phosphorus than was true years ago. The supply of these minerals in the common feeds, particularly roughages and pasture grasses, has decreased because of the gradual depleting of the calcium and phosphorus content of the soils on which they are grown. Also, the requirements of dairy cows for

[1]More complete information on minerals for livestock is given in Cornell Extension Bulletin 550, *Meeting the Mineral Needs of Farm Animals*, by L. A. Maynard and J. K. Loosli. (Revised 1949.)

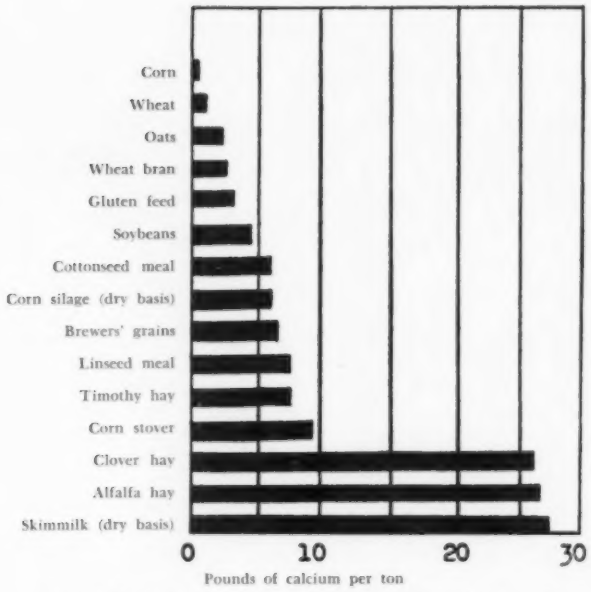

Figure 3. Calcium content of common feeds. Legume hays are the richest sources of calcium. Farm-grown grains are poor sources.

these minerals have become greater as the rates of milk production have increased through better breeding, feeding, and herd management. With these conditions of increased demand and decreased supply, injurious effects of a deficiency of one or the other of these minerals have become apparent and have demonstrated the necessity of providing them in the ration.

When the ration is low in calcium and phosphorus, the cow draws upon her bones in an attempt to cover the shortage. When the requirement is greatest, during periods of heavy milk production, the reserve stored in the bones is depleted somewhat and built up again toward the end of the lactation and during the dry period if the opportunity is provided. Because of the large supply available in the bones, a lack of either calcium or phosphorus in the feed will not immediately result in a decrease in milk production. If the demand, however, is great enough, both the production and the animal will eventually suffer. Even liberal feeding of minerals to high-producing cows will not prevent losses of calcium and phosphorus from their bodies during the early part of lactation. These losses cease as milk production decreases, and they can be replenished by continued liberal feeding of feeds containing calcium or phosphorus or of mineral supplements. A dry period is necessary so the reserve can be built up from a ration that furnishes plenty of these minerals.

When rations are extremely low in calcium or phosphorus, or both, the bones may become so weakened they break easily and may result in the death of the

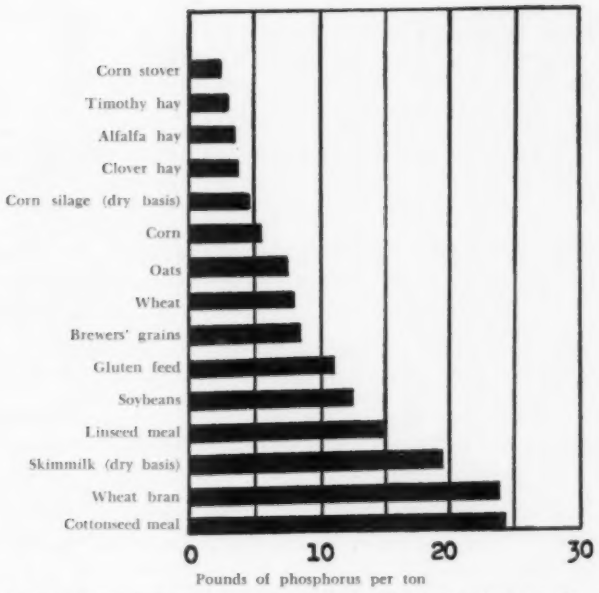

Figure 4. Phosphorus content of common feeds. High-protein feeds are the best sources of phosphorus for dairy cows. Farm-grown hays and grain are relatively poor sources.

animal. Sometimes the results may not be so severe, but the losses may not be restored and it becomes difficult to maintain milk production. The lack of these minerals results in lower milk yield rather than in milk low in calcium and phosphorus. Smaller deficiencies of these minerals may not become apparent until after several years.

Under most feeding conditions, phosphorus is more likely to be lacking than is calcium. Few cases of calcium deficiencies in dairy cows have ever been reported. If, however, there is a deficiency, ground limestone is a satisfactory supplement and usually is the cheapest source of calcium.

The most common symptoms of phosphorus deficiencies in dairy cattle are a loss of appetite and a tendency to chew wood, bones, and other objects. There may be a stiffness in the joints and a run-down unthrifty condition. In extreme cases of phosphorus deficiency, animals may become listless and have but little desire for food. Also, there may be some interference with reproduction in extreme phosphorus deficiency.

The relative amounts of calcium and phosphorus in common feeds are shown in figures 3 and 4. It is obvious that the first consideration in meeting the mineral needs of dairy cows is to furnish legume or mixed grass-legume hay. This is the cheapest and best way to furnish plenty of calcium. If the roughages fed contain some legumes, there is no need for any calcium supplement.

Liberal feedings of concentrate mixtures that contain appreciable amounts, one-fourth or more, of wheat bran or oil-meal feeds supply plenty of phosphorus.

The use of a phosphorus supplement toward the end of lactation, during the dry period, or for cows on pasture when lower amounts of grain may be fed is often a wise procedure. The one most commonly used is:

100 pounds of steamed bone meal, or dicalcium phosphate
100 pounds of salt

Mineral boxes in pastures should be protected from the weather. If any of the various rock phosphates are used as phosphorus supplements, they should be those free from fluorine.

Iodine

A small amount of iodine is needed in the ration of dairy cows. Iodine deficiencies have been reported in some parts of New York so it is best to add an iodine supplement to the ration of pregnant cows. A lack of it during gestation may cause goiter in calves.

The simplest way to provide iodine is to feed stabilized iodized salt (salt containing 0.01 per cent of potassium iodide). Practically all salt companies market such a product which can be obtained readily from feed stores.

Frequent claims are made that certain organic forms of iodine are superior to potassium iodide in preventing goiter and in providing other special benefits. Experimental evidence does not justify these claims.

Cobalt

Cobalt, too, is an essential mineral element for dairy cattle. Deficiencies have been found in cattle and sheep in a few areas in New York and other States where the soils and crops are very low in this element.

Deficiency symptoms are similar to those from underfeeding or from other nutritive deficiencies. The animals lose appetite and weight, become unthrifty and emaciated, and often have a desire to gnaw on wood. Cattle lacking this mineral respond quickly when fed cobalt. The exact functions of cobalt are still unknown. Theories have been advanced that cobalt functions primarily through some influence upon the microorganisms in the paunch.

Cobalt may be added in several ways. Probably the best procedure is to feed cobalt in the salt mixture; such as:

100 pounds of steamed bone meal, or dicalcium phosphate
100 pounds of salt
½ ounce of cobalt sulfate

In some areas mixtures of this type may be purchased already mixed. To mix this small amount of cobalt with the salt at the farm, it is best to dissolve the cobalt sulfate in a little water, spray it over the salt with a small fly sprayer, and then mix the salt well. Thorough mixing is essential.

For animals already suffering from cobalt deficiency, a drench may be desirable. One teaspoonful a day of a solution containing 1 ounce of cobalt sulfate in each gallon of water is enough for each cow.

Cattle that have plenty of legume roughage seldom lack cobalt.

Other trace minerals and mineralized salts

In addition to iodine and cobalt, claims are often made that additional trace minerals, such as iron, copper, manganese, and zinc, should be added to dairy rations. Often they are recommended on an "insurance" basis.

Salts with added trace minerals are now on the market in both loose and block form. Generally, they consist of ordinary salt, enriched with iron, copper, iodine, cobalt, manganese, and zinc. Such a mixture usually furnishes these trace minerals at minimum cost if they are needed.

Of these trace elements, iodine and cobalt may be lacking, as already pointed out. So far as is known at present, copper is deficient only in parts of Florida. There is no evidence that dairy cattle need extra manganese, iron, or zinc over the amounts supplied by the usual feeds. Therefore, a wise procedure is to add to the ration only those minerals which experiments and experience indicate may be lacking from normal rations fed to dairy cattle. Just because an element may be lacking in one small area of the country is no indication that it should be added universally to dairy rations.

Mineral feeds and stock tonics

Many complex mineral mixtures, mineral feeds, and stock tonics are on the market. Most of these mixtures contain a large number of substances in addition to the elements required. An animal receiving a normal ration of good-quality feeds ordinarily needs no tonic or appetizer. If good-quality feeds are not available, money might be used to better advantage for the purchase of feeds rather than for expensive tonics or complex mineral mixtures.

There is no objection to a proprietary mineral mixture, provided the farmer can get the minerals that are actually needed at a reasonable price, but there is no advantage in buying at high prices substances that are not needed in the ration.

Vitamins

Of the many vitamins dairy cattle need, vitamin A and vitamin D are the only ones that *may* be lacking in practical rations. Even vitamin A and especially vitamin D are seldom lacking in dairy rations.

Many, if not all, of the B-complex vitamins are known to be synthesized in the rumen of the dairy cow. Vitamin C has never been shown to be required in the rations fed to farm animals. Adequate information has not been obtained to show that dairy cattle need supplemental sources of vitamin E.

Vitamin A

Vitamin A is necessary for growth and for the maintenance of health in mature animals. It is also necessary for normal reproduction. Calves may be born dead or in a weakened condition because of a lack of vitamin A in the ration of cows during pregnancy. Calves have been known to be born blind because of a lack of vitamin A in the ration of the cows.

Fairly liberal amounts of carotene are advisable in the ration during the latter stages of pregnancy because it increases the vitamin-A store in the newborn calf and in colostrum milk.

Of some practical significance is the fact that the vitamin-A potency of milk is proportional to the amount of carotene in the ration. Feeds rich in carotene, therefore, such as legume or grass silage, corn silage, and green, leafy hay, are essential in winter feeding for the production of milk with yellow color and high vitamin-A value.

Fortunately, a plentiful amount of vitamin A is supplied to dairy cows when they are receiving good pasture during the summer season and if they are fed a

reasonable amount of good hay, with or without silage, during the barn-feeding season. These roughages supply liberal amounts of carotene which is readily converted to vitamin A in the animal body.

Results of experiments and experiences of dairy farmers show that if cows have reasonably good pasture in summer and if one-half of their roughage during the winter is good-quality hay or silage, there will be no deficiency of vitamin A. Cows can store large quantities of vitamin A in their bodies during the summer when on pasture which may be drawn upon during the winter months when the supply in the feeds may be reduced.

In exceptional cases where pasture is poor or lacking during the summer and where no silage or good-quality hay is fed during winter, there might be a vitamin-A deficiency. Under such conditions, a commercial source of carotene or vitamin A might be fed unless good-quality hay or silage was obtainable.

Vitamin D

Vitamin D is essential for the proper utilization of calcium and phosphorus and for the proper development of the skeleton. The need is greatest for young, growing animals rather than for mature cows, but some experiments have shown that cows, too, have a definite need for the vitamin.

Vitamin D may be obtained either in the feeds or by direct exposure to sunlight. Sunlight acts on a chemical substance in the body and produces vitamin D. The chief feed source of the vitamin is sun-cured hay. Vitamin D is produced in the hay by the action of sunlight during the curing process. While hay crops apparently vary in their vitamin-D content, any hay crop cured in the sun supplies enough to meet the requirements of cows if a few pounds of the hay are fed each day.

In spite of some claims to the contrary, probably under usual farm conditions enough vitamin D is supplied to dairy cows by sun-cured roughages or is provided by the action of sunlight. Based on present information, there is no need for vitamin-D supplements for mature dairy cows except for the production of special "vitamin-D milk."

Vitamin E

The fact that a deficiency of vitamin E leads to reproductive failure in rats and poultry has led many commercial interests to claim that it is a cause of sterility and breeding troubles in dairy cattle. There is no good evidence that vitamin-E deficiency contributes in any way to sterility in dairy cows. Experiments have shown no value in using wheat-germ oil or vitamin-E supplements to prevent or cure breeding troubles in cattle.

Some recent experiments have shown a possible favorable effect of commercial vitamin-E products (tocopherols) upon the keeping qualities of milk. More information is needed for practical application.

Water

The importance of an abundant supply of water for the cows during the hot summer days and in the barn in the winter is frequently overlooked. Cows may need 80 per cent more water on hot days than on cooler and more comfortable days.

Figure 5. Improved permanent pastures yield well until growth is retarded by hot and dry weather.

Milk is 87 per cent water, therefore dairy cows have a high requirement for water. The body of the cow is about one-half water. Including both the water in the feed consumed and the water they drink, cows will usually consume from 3.5 to 5.5 pounds of water for each pound of milk produced. The actual amount of water consumed depends upon the size of the cow, the milk production, the amount of water in feeds eaten, and on the temperature of the air.

Experiments have shown that providing water to cows in automatic drinking bowls increased milk yields from 3.5 to 4.0 per cent over watering them twice daily, and from 6 to 11 per cent over watering them once daily. If water bowls are not used, good cows should be watered at least twice a day and allowed all they will drink each time.

Roughages

Pastures

Importance of good pastures

Pastures on New York dairy farms are the most important source of lowest cost nutrients. Pastures furnish about 28 per cent of the total digestible nutrients eaten yearly by cows in New York Dairy Herd Improvement Associations.

The use of pasturable crops that furnish ample amounts of nutritious and palatable green feed throughout the entire pasture season materially increases the annual production of dairy cows at a relatively low cost. To make this kind of pasture feed available is good farming and on most farms will do more to make dairying profitable than will improvement in any other single feeding practice.

Figure 6. Ladino-clover–grass pasture provides liberal amounts of feed.

Succession of pasture crops

Neither improved permanent pastures nor any other one pasture crop furnishes enough grazing throughout the pasture season; therefore, a succession of pasturable crops must be grown. These must be well adapted to soil and climatic conditions and must produce maximum growth under the varying weather conditions that prevail during the spring, summer, and fall months.

Legume and legume-grass seeded pastures, meadow aftermath from good seeding mixtures, oats, and Sudan grass, properly grown and grazed, furnish in succession an abundance of palatable feed. These crops grazed at right stages are high in protein and carotene and low in fiber. Improved permanent pastures will not make enough growth for good pasturing during hot or dry weather. Without a succession of well-grown and managed pastures, full production can be maintained only in high-producing cows by the supplemental feeding of good hay, corn or hay-crop silage, and soiling crops, or by heavy grain feeding.

Hay

Quality of hay and feeding value

Hay is the most important harvested forage crop in the dairy ration. New York farmers grow many more acres of hay than they do of all other harvested crops put together. There is a great difference in the quality of the same variety of hay as grown and harvested on different farms in the same season and on the same farms in different seasons. Hay varies more in feeding value and in palatability than does any other feed commonly used in dairy-cattle feeding.

The quality of a hay depends largely on the time it was cut and on its leafiness and color when fed. Good hay is palatable, and has a higher content of digestible nutrients and less indigestible material than has a poorer quality hay. There is a great difference in feeding value of early-cut, fine-stemmed, leafy hay and late-cut coarse-stemmed hay. Early cutting does not guarantee the harvesting of good hay, but it is essential to really good hay. The comparative feeding value of hays of different qualities is given in table 3 (page 33).

The variety of hay is of less importance in determining its quality than is the time of cutting and the methods used in harvesting. Crops that are ordinarily grown for hay contain about the same proportion of total digestible nutrients if they are of the same quality. Hays of different varieties, however, differ materially in their protein, mineral, and vitamin content. It is not necessary to feed more concentrates with one variety of hay than another if they are of the same quality and palatability and if equal amounts are consumed. The concentrate or grain mixture must, however, vary in protein, mineral, and vitamin content to make up properly for deficiencies of these materials in the hay being fed.

Legume or non-legume hays

While legume hays contain no more total digestible nutrients than do non-legume hays of equal quality, they have many other advantages that make them more valuable: (1) they produce larger yields per acre, particularly in dry seasons; (2) they contain a higher proportion of protein; (3) they contain more calcium or lime; (4) they have a higher vitamin content when properly cured; and (5) they enrich soils in nitrogen content.

Mixed hays

Mixed hays contain both legume and non-legume plants and are those most used by New York dairymen. These hays are usually a combination of one or more legumes, such as alfalfa, ladino, medium red clover, or alsike clover mixed in varying proportions with timothy or smooth brome grass.

A good-quality mixed hay that contains at least one-third legumes is excellent for dairy cows. Such hay is preferred by many dairymen because they think their cows prefer it to straight legume hay and eat more of it. Some also think mixed hay is easier to handle and to cure properly than are legume hay crops. Many soils are better adapted to the growing of legume-grass mixtures than to legumes alone.

Chopping and grinding hay

Neither chopping nor grinding hay increases its nutritive value. Either insures heavier consumption of poor-quality hay. Chopped hay takes up only about one-half as much space in the mow as does long hay, and it is convenient to handle. Care must be taken to have hay that is to be cut into the mow as dry as when put in long, and preferably drier. Also, it is well to be sure that the joists under the haymow will stand the extra strain.

Ground hay cannot take the place of grain in the grain mixture. It is still a roughage with a high proportion of crude fiber.

Corn Silage

Corn silage is a valuable feed in the dairy ration, particularly if the quality of the hay fed is not good. Because of its high moisture content, silage contains

only one-third as much total digestible nutrients as does hay. When fed with palatable hay of good quality, silage is worth one-third as much as hay in feeding value. It is worth more than one-third when its palatability and laxativeness correct deficiencies in poor hay.

Corn silage should be harvested when the kernels are reaching the glazed or early-dent stage. If cut into the silo too early, an excess of moisture results and sourer silage is produced. If cut too late, a dry and less palatable silage results and the silage may mold unless water is added.

Hay-crop Silage

Recently much attention has been given to develop ways to ensile the usual hay crops. The ensiling and feeding of legume and non-legume hay crops have many advantages, particularly in those sections where it is difficult to cure early-cut hay properly because of adverse weather. The chief advantage is that the hay crop is cut early in the season when it has its highest feeding value, and, if properly ensiled, most of the nutrients are saved. Furthermore, when part of the early hay crop is cut for silage, the second growth is usually better and may be grazed in midsummer or cured into hay at a better time of year for field curing. Making hay-crop silage helps to use farm labor more efficiently and helps to control weeds on the farm. If legume or grass silage is fed during the summer months as a supplement to pasture, the silo will be ready for corn silage in the fall.

Figure 7. Hay-crop silage conserves nutrients and is a valuable roughage for feeding in all seasons of the year.

Making good hay-crop silage

Good silage can be made from hay crops but with possibly greater difficulty than with corn silage. Legumes and early-cut grasses are much lower in sugar than is corn cut at the proper stage for silage. Because of the low sugar content, enough lactic and acetic acids may not form to keep the hay-crop silage from spoiling or from having strong, undesirable odors.

Legumes and grasses often are too high in water content when cut for the best quality of silage. The dry-matter content needs to be about 30 to 35 per cent. Early-cut immature crops may run as low as 20 to 23 per cent of dry matter. Such immature crops need some wilting to get rid of the excess water.

The lack of sugar and other carbohydrates in legumes and early-cut grasses can be corrected by the addition of preservatives, such as cane molasses or ground cereal grains. Enough acids are formed from either one of these products in the fermentations in the silo to preserve the silage

properly. Preservatives also help to produce a good-smelling silage that may be more palatable. Good silage can, however, be made either with or without a preservative. Also, bad silage can be made either way.

If molasses is used as a preservative, from 60 to 70 pounds needs to be added to each ton of legume-grass mixtures or early-cut grasses and about 80 to 90 pounds for alfalfa or other legumes. Where hominy feed, ground corn-and-cob meal or other ground grain is used, from 100 to 125 pounds is enough for legume-grass mixtures and from 125 to 150 pounds for alfalfa and other legumes.

Among other products that have been used as satisfactory preservatives is dried whey; about 20 pounds to each ton for grasses up to 40 pounds for legumes is recommended.

Preservatives will not prevent molds in silage. Tight silos, correct dry-matter content, and proper packing are necessary to exclude air for the prevention of molds.

Feeding value of hay-crop silage

More total roughage is eaten and liveweights are maintained better when dry hay is fed with hay-crop silage than when the silage is fed as the only roughage.

Hay-crop silage is generally worth slightly more, on a dry-matter basis, than good hay made from the same crop. When added to a ration of hay and concentrates, milk production usually is increased slightly. A good succulent feed exerts a favorable effect on milk yield.

While some experiments have shown hay-crop silage equal to corn silage for milk production, most have favored well-eared corn silage. The milk yield has been slightly higher on corn silage and cows maintained their weights better than on hay-crop silage. Some of this could be prevented by increasing the allowance of grain with hay-crop silage to offset that in corn silage.

The amount of protein needed in the concentrate mixture is less when cows are fed silage made from legumes or legume-grass mixtures than with corn silage. This often is overlooked by dairymen.

The carotene content of the crop is preserved to a better extent in legume and grass silage than in dry hay. Thus, the feeding of this silage may be of value in increasing the color and vitamin-A value of the milk.

Characteristics and Feeding Value of Concentrate Feeds

Concentrated feeds, such as grains and by-product feeds, are highly important for dairy cows. High-producing cows have a high energy requirement and it is necessary that part of the ration consist of high-energy concentrates. Roughages are bulky and too low in energy value to maintain continued high milk yields if fed alone. The intelligent use of concentrates enables the dairyman to make up a mixture that will properly supplement the available roughage nutrients and meet the requirements of each cow.

To provide satisfactory rations, one should know the characteristics and feeding value of the most common dairy feeds. The average composition and digestible nutrient content of these feeds are given in table 7 (pages 45 and 46).

Farm Grains and Seeds

The cereal grains, including corn, oats, barley, and wheat, are excellent feeds for milk production. They are palatable, rich in carbohydrates and, therefore,

high in energy or total digestible nutrients. They are low in fiber and minerals and are comparatively low in protein. Because they are low in protein, cereal grains generally have to be mixed with other feeds higher in protein to make satisfactory grain mixtures for dairy cattle.

Corn

Corn stands at the head of the list of farm-grown grains in palatability and total digestible nutrients. When corn is used as the chief concentrate feed in the grain mixture, deficiencies in minerals and protein must be fully corrected. Legume hay makes good all the deficiencies of corn, except those for phosphorus.

Most dairymen prefer to use corn only as a part of the grain mixture, mixing it with more bulky feeds, such as bran or ground oats, because it is a rather heavy feed. Corn should always be ground, and ground only to a medium degree of fineness, because extremely fine grinding is unnecessary and is expensive.

Corn-and-cob meal

When fed in a grain mixture that is already reasonably bulky, corn-and-cob meal is apparently worth a little less than an equal weight of ground corn. When, however, other bulky feeds are not mixed in the ration, corn-and-cob meal may practically equal ground corn in feeding value. If the cost of grinding ear corn into corn-and-cob meal is less than the cost of shelling the corn and then grinding, it is economical to use the corn-and-cob meal.

Barley

Ground barley is practically equal to ground corn in feeding value for dairy cows and may be substituted for it pound for pound in the grain mixture. It is higher in protein than corn but slightly lower in total digestible nutrients. Barley should be ground to a medium fineness or crushed before it is fed.

Oats

Ground oats are somewhat higher in fiber than are the other cereal grains but are higher in protein than is corn. Oats are a palatable feed and add bulkiness to the grain mixture. Although they are somewhat lower than corn in total digestible nutrients, they are worth almost as much as corn in the grain mixture.

Wheat

Wheat has been a common feed in recent years. It is about equal to corn in feeding value and is satisfactory in the grain mixture. It is higher than corn in protein but not so palatable. When wheat is available and the price permits, it can be used to good advantage, preferably in amounts of not more than one-third of the grain mixture. Wheat is a heavy feed and should be ground and mixed with bulky feeds. When ground, it should be in a gritty or mealy condition.

Rye

Rye is similar to the other cereal grains in furnishing nutrients but is not so palatable. When the price of rye is less than that for the other grains, it can be used to good advantage in the grain mixture. Rye should not make up more than 25 per cent of the mixture. When fed as a part of the mixture, ground rye is practically equal to ground barley or ground corn for dairy cows.

Buckwheat

Buckwheat is not so palatable as most of the grain feeds. It should be mixed with other feeds but should not form more than 15 per cent of the grain mixture. Ground buckwheat is about equal to oats in protein content but is somewhat lower in total digestible nutrients. When fed in a suitable mixture, buckwheat makes a satisfactory feed for dairy cows and is worth about 10 to 15 per cent less than oats.

Soybeans

When fed in such amounts as are necessary to balance the ration, ground soybeans are well liked by dairy cattle and provide an excellent home-grown protein supplement. Soybeans furnish proteins of excellent quality that balance the deficiencies of farm grains, and they are equal to linseed meal and cottonseed meal as a protein supplement for dairy cows. Soybeans are also especially valuable for their high fat content.

By-product Feeds

Many by-products are used for dairy-cattle feeds, but only the most important ones are discussed here. These feeds vary in their composition and feeding value according to their source and the manufacturing process employed.

Hominy feed

Hominy feed is obtained in the manufacture of cornmeal for human use, and contains a mixture of corn bran, corn germ with or without the oil, and some of the starchy portion of the corn kernel. The product is kiln-dried and keeps better in storage than does ground corn or cornmeal. Hominy feed is similar to corn in composition and is equal to or slightly superior to corn in feeding value. Hominy feed furnishes about the same amount of total digestible nutrients as does corn and is somewhat more bulky.

Dried beet pulp

Dried beet pulp is liked as a food for dairy cattle because of its bulky nature and its palatability. When used in relatively small amounts to add bulk and palatability to the grain ration, it may be worth fully as much as corn. Dried beet pulp is low in protein, high in fiber, but furnishes about the same total digestible nutrients as oats. Its price often prohibits its use. When silage or other succulent feed is not available, dried beet pulp, soaked in water before feeding, is often used as a substitute for silage. When fed in this way, soaked beet pulp is palatable and has a good conditioning effect.

Some of the beet pulp on the market has a small amount of molasses added. There is no difference in feeding value between this and regular beet pulp.

Dried citrus pulp

Citrus pulp, a by-product of citrus-fruit-canning factories, is made chiefly from grapefruit and orange residue. It consists of the peel, the residue of the inside portion, including the seeds, and occasional cull fruits. The pulp is generally dried and ground and sold as dried citrus pulp.

Dried citrus pulp resembles dried beet pulp in composition and feeding value. It is not so palatable as beet pulp, but experiments indicate no great difficulty in getting cows to eat concentrate mixtures containing citrus pulp. It is better to

feed citrus pulp in concentrate mixtures than to try to soak it before feeding as is done with beet pulp.

Cane molasses

Cane molasses is low in protein and furnishes only three-fourths as much total digestible nutrients as does corn. Because of its lower nutrient content, cane molasses is worth somewhat less than corn pound for pound in a good, palatable dairy ration. Some experiments have shown that it is worth about 89 per cent as much as corn. When, however, cane molasses is used as an appetizer to increase the palatability of other feeds, it has a much higher feeding value. Cane molasses is often diluted with warm water and sprinkled over poor-quality and unpalatable hay and other roughage which the cows might otherwise waste. When used in this way, cane molasses is worth fully as much as corn and frequently furnishes a cheap source of nutrients.

Wet brewers' grains

Wet brewers' grains vary in water content but usually contain, on an average, from 70 to 75 per cent of water. They are approximately equal in feeding value to corn silage and may be fed safely up to 25 to 35 pounds per head daily to dairy cows. Wet brewers' grains are worth approximately one-third as much as hay in feeding value. They are worth about one-fourth as much as dried brewers' grains. Wet brewers' grains may replace silage in the ration, may replace part of the hay at the rate of 3 pounds of the grains to 1 of hay, or they may be fed to replace part of the grain mixture, feeding 4 pounds of the wet grains to replace 1 pound of the dry grain mixture.

Wheat bran

Wheat bran is one of the most popular of dairy feeds. It is palatable, bulky, and slightly laxative; rich in phosphorus; and medium high in protein. Wheat bran furnishes about the same amount of total digestible nutrients as does oats but is somewhat more bulky. It has its greatest value in the concentrate mixture when it forms no more than one-fourth or one-third of the concentrate mixture. When used in greater quantities the cost of nutrients may be too great, because it is not particularly high in total nutrients.

Wheat middlings and wheat mixed feed

Although standard wheat middlings are not commonly fed to dairy cattle in large amounts, they provide an excellent feed when they form no more than one-third of the grain mixture. They furnish somewhat more total digestible nutrients and a little more protein than does bran, but they are less bulky and slightly less palatable than bran. When they can be purchased for the same price as bran, middlings may be substituted for part or all of the bran, thus providing more nutrients in the mixture, unless the bulkiness furnished by bran is essential.

Wheat mixed feed consists of the wheat bran and the flour middlings in the proportions usually obtained from the process of commercial milling. In furnishing total digestible nutrients, wheat mixed feed is worth from 5 to 10 per cent more in the ration than is wheat bran.

Distillers' dried grains

Distillers' dried grains that are produced chiefly from corn differ markedly in feeding value and composition from those made from rye; therefore, they should

be designated as *distillers' dried grains from corn or distillers' dried grains from rye,* depending on the predominating grain.

In the process of manufacture, the distillers' solubles may be added to the wet grains and the mixture then dried to form dried distillers' grains with solubles, or dark distillers' grains. Sometimes the distillers' grains are dried without the solubles. This product is known as *dried distillers' grains without solubles,* or *light distillers' grains.* For dairy cattle, there is little, if any difference in feeding value between the light and dark grains.

Distillers' dried grains from corn are considerably higher in feeding value than are the rye grains, for they are higher in fat, protein, and total digestible nutrients, and much lower in fiber content. A good grade of the corn distillers' grains should furnish at least 8 per cent of fat and not less than 28 per cent of protein. Some of the distillers' grains do not come up to this standard, and should therefore be bought on the basis of guaranteed composition. Because of the importance of enough fat in the grain mixture, distillers' dried grains from corn are particularly useful in the ration.

Brewers' dried grains

Brewers' dried grains are a bulky feed and often provide an economical source of protein for dairy cows. As compared with corn distillers' grains, they are not so palatable, are higher in fiber, and are lower in protein and total digestible nutrients. When they can be purchased economically, however, dried brewers' grains give excellent results if they form not more than one-third of a suitable concentrate mixture.

Coconut oil meal

Coconut oil meal furnishes somewhat less protein than does corn gluten feed, averaging about 21 per cent. The meal prepared by the hydraulic or expeller processes contains from 6 to 7 per cent of fat. This feed gives excellent results for dairy cows and is about equal to corn gluten feed in feeding value. Coconut oil meal may possibly increase the butterfat test slightly.

Corn gluten feed

Of the high-protein dairy feeds, corn gluten feed is one of those fed most commonly. It furnishes only about three-fourths as much protein as does linseed meal. Hence, it is worth somewhat less a ton as a protein supplement. Corn gluten feed is not particularly palatable and, since it is from corn, does not furnish proteins of good quality. This deficiency in the quality of the protein can, however, be made up with legume hay, and the feed gives excellent results in the grain mixture with feeds such as oats, wheat bran, linseed meal, and other palatable feeds with good-quality protein.

Linseed meal

Among dairy feeds, old process linseed meal is without question one of the most popular and also most valuable. Because of this, linseed meal is often relatively expensive as compared with some of the other feeds. Its popularity is due to its richness in protein, its palatability, and its conditioning and laxative effects. Linseed meal is also high in phosphorus content, and is particularly useful in fitting rations and in rations for cows on official test.

Cottonseed meal

Cottonseed meal has long been used as the cheapest source of protein in the Southern States, and is also commonly used in other sections. It is rich in protein of fairly good quality and gives excellent results with dairy cows. Cottonseed meal is one of the best sources of phosphorus in feeds.

Contrary to many opinions, experiments have shown that feeding of cottonseed meal does not increase the tendency for mastitis or for other udder troubles. Also, experiments indicate that it does not have a constipating effect as has been the common belief.

Soybean oil meal

The production of soybean oil meal has increased so rapidly in recent years that it is now the most important high-protein supplement. Soybean oil meal is rich in protein and fulfils all the requirements of a desirable protein supplement; it is palatable, has a good conditioning effect, has a high digestibility, furnishes well-balanced proteins, and is a fairly rich source of phosphorus. It is fully equal to linseed meal or cottonseed meal in feeding value.

Soybean oil meals on the market now may have been made by one of three methods: the hydraulic process, the expeller process, or the solvent process. The solvent process has been used more extensively in recent years and more than one-half of the meal now available is produced by this process. Solvent-process meals are higher in protein, but much lower in fat, than those made by the expeller or hydraulic processes. If enough fat is provided by other feeds, probably there is no difference in feeding value between solvent-process soybean oil meal and those manufactured by the other processes.

Buying Feeds on the Basis of Nutritive Value

To obtain the largest returns on money invested in feeds, the dairy farmer must know the nutritive requirements of his cows (page 47). He must study the possibilities of his farm for raising the maximum production of feed crops, particularly pasture, hay, and silage. He needs to consider the feeding value of the many feeds on the market and to select the most efficient feeds and rations that furnish the most nutrients for each dollar spent. Since feed costs amount to about one-half the total costs of producing milk, every dollar that can be saved by careful selection of feeds is important.

Market Prices Not Always the Best Guide

To obtain maximum returns from the dairy-farm business, careful attention must be given to feed prices. A certain combination of feeds may be the cheapest this year but next year the same feeds may be the most expensive. Market prices of feeds are constantly changing, and the wise feeder makes changes in his rations to meet these conditions. He calculates the cost of nutrients in the various feeds before he purchases them. There is no one "best" ration for dairy cattle. Many combinations of feeds can be made that are well balanced and efficient.

Of the several ways to calculate which feeds are actually the cheapest to buy, the most common is to determine the cost of total digestible nutrients in feeds. Such a method, of course, has many limitations, especially when the high-protein feeds are high in price. If, however, the feeds selected are satisfactory in quality,

are well suited to the animal, and furnish the most total digestible nutrients at the least cost, with enough protein, this method is satisfactory for all practical purposes.

It is simple to calculate the cost of total digestible nutrients in a feed. For example, corn may be selling for $3.00 a hundredweight. According to table 7 (page 46) 100 pounds of No. 2 corn, on an average, contains 80.1 pounds of total digestible nutrients. Dividing $3.00 by 80.1, one obtains $0.0375, the cost of a pound of total digestible nutrients. Multiplying this cost by 100, indicates that 100 pounds of total digestible nutrients in corn costs $3.75 when the market price is $3.00 a hundredweight. For comparison, suppose barley is selling for $3.25 a hundredweight. With the same sort of calculations, 100 pounds of total digestible nutrients in barley would cost $4.18. Therefore, corn would be the better feed to buy. By similar computations for the other feeds, the feeds furnishing nutrients for the least cost can be determined.

This method may be used by the dairyman who is buying individual ingredients and mixing his own grain ration. Also, it can be used by the individual who raises oats and barley, or other farm grains, and is interested in the cheapest protein supplements to add to his home-grown grains in order to make up an efficient combination of feeds.

Formula Feeds

Many commercial mixed feeds are on the market, and most of them are made up of high-quality ingredients and produce excellent results. In purchasing formula feeds one should consider the reputation and reliability of the manufacturers and then select the best possible mixtures at least cost. It is practically impossible to look at a bag of mixed feed and determine the quality of ingredients or the feeding value. The integrity and reliability of the company must be relied upon.

Nearly all the States have laws governing the sale and manufacture of mixed feeds. In New York the minimum amounts of protein, and fat, the maximum amount of fiber, and a list of the ingredients must be given on the feed tag. Some of these mixed feeds are known as *open-formula feeds*. They give the amounts of each ingredient used in the mixture and often calculate the percentage of digestible protein and total digestible nutrients.

In deciding whether to buy a formula feed or to mix a suitable ration himself, the dairyman should base his decision on the cost of the individual ingredients in his home mix plus the labor involved. Often a high-grade mixed feed can be purchased at little or no more additional cost than if the dairyman mixed it himself. The careful feed manufacturer handles large volumes of feed and, with his knowledge of feeds and prices, is able to put on the market good-quality feeds that furnish nutrients at low cost.

The feed manufacturer is in a position to make such changes in his formulas as are necessary to provide efficient mixed feeds at a minimum price. He usually changes his formulas in accordance with supplies and prices of ingredients for the benefit of the feeder.

In buying formula feeds one should try to buy the most total digestible nutrients for each dollar spent, provided enough protein and the other essentials in the mixture are met. One should examine the feed tag to determine the guaranteed percentages of protein, fat, and fiber. A low percentage of fiber and a high

percentage of fat are indications of a high total-digestible-nutrient content. Generally speaking, formula feeds should contain about 4 per cent of fat and not more than 9 or 10 per cent of fiber. With a larger proportion of the oil meal feeds now being made by the solvent extraction process, it has become increasingly difficult for feed manufacturers to put out formula feeds containing 4 per cent of fat. As a result, many good and high-quality mixtures may contain as little as 3 per cent, or even less, of fat.

Relative Value of Concentrates and Roughages

When grain prices are high in certain seasons and years or when the supply of hay is short, questions often arise as to the relative value of concentrates and roughages. Good-quality hay of any kind furnishes about 50 per cent of digestible nutrients; therefore, a ton of hay contains about 1000 pounds of nutrients. In comparison, a concentrate mixture is about 70 to 75 per cent digestible. A ton, therefore, contains from 1400 to 1500 pounds of total digestible nutrients.

A ton of good hay, therefore, contains about two-thirds as many nutrients as a ton of a good concentrate mixture. Because of the higher fiber content, a pound of total digestible nutrients in hay is not fully equal to a pound of nutrients in grain; yet for all practical purposes this two-thirds value is satisfactory. If hay is low in quality then it may be worth only 40 to 50 per cent as much as a concentrate mixture.

Under most conditions, nutrients can be purchased more cheaply in hay than in concentrates. This applies even in some of the commercial dairy areas where all roughages and other feeds are purchased.

A Simple Way to Formulate Grain Mixtures

Many dairymen producing home-grown grains ask for information on the best way to use them in a grain mixture to obtain good results. Any attempt to suggest a number of dairy rations made from home-grown grains as the basis falls short of the dairymen's needs, because of the difference in the types of roughage being fed and the variation in the price of individual feeds. With this in mind, the following suggestions are given to enable any dairyman to make a satisfactory ration on the farm from any combination of home-grown grains and individual feed ingredients without knowing the exact composition, and without bothering with many calculations. A good grain mixture may be formulated to suit any available combination of roughages.

Characteristics of a Good Grain Mixture

The essentials of a good mixture are:

Enough total digestible nutrients in high-quality, palatable ingredients.

Plenty of digestible protein to supplement that furnished by the roughages fed.

Enough fat in the concentrate mixture. Four per cent of fat is preferable if it can be obtained without increasing the cost unduly.

Variety of feeds in the mixture. While not always essential, variety often adds to palatability.

Enough minerals, especially salt and phosphorus, and sometimes cobalt.

Bulkiness in the grain mixture. This is desirable but not necessary.

Low cost. This is one of the most important essentials, and dairymen should meet all of the requirements with the cheapest possible mixture.

Classification of Concentrate Feeds

For feeding purposes, individual feeds are often classified on the basis of their protein content:

Low protein	*Medium protein*	*High protein*	*Very high protein*
Barley	Wheat bran	Corn gluten feed	Cottonseed meal
Oats	Standard wheat middlings	Brewers' dried grains	Linseed meal
Corn	Rye middlings	Dried distillers' grains (corn)	Soybean oil meal
Wheat	Wheat mixed feed	Buckwheat middlings	Corn gluten meal
Rye		Coconut oil meal	Ground soybeans
Buckwheat		Field beans	
Hominy feed			
Corn-and-cob meal			
Cane molasses			

For the dairy cow any feed in any one of these four groups is approximately equal in feeding value to any other feed in the same group. One should keep in mind the characteristics of the different feeds and the essentials of a good ration and then select from these groups the feeds that furnish the cheapest nutrients to give the desired protein content in the grain mixture.

The proportions of the low-protein, medium-protein, high-protein, and very high-protein feeds that are needed to give a grain mixture the proper content of protein required with the various combinations of roughages are given in table 1.

TABLE 1. PERCENTAGE OF PROTEIN FEEDS NEEDED WITH VARIOUS ROUGHAGES TO GIVE THE PROPER PROTEIN CONTENT TO THE GRAIN MIXTURE

Kind of roughage	Low-protein feeds	Medium-protein feeds	High-protein feeds	Very high-protein feeds
	Per cent	*Per cent*	*Per cent*	*Per cent*
Non-legume hay and corn silage	40	15	25	20
	45	10	20	25
Mixed hay containing 30 per cent legumes and corn silage	50	15	25	10
	60	5	25	10
Clover hay and corn silage	60	15	15	10
	65	10	20	5
Alfalfa or soybean hay and corn silage	70	25	5	—
	80	15	—	5

The following concentrate mixture illustrates the use of table 1 and shows the percentage of the different groups of feeds given in table 1 for mixed hay and corn silage.

EXAMPLE. Mixed hay and corn silage

50 per cent low protein	500 pounds ground barley 500 pounds ground oats
15 per cent medium protein	300 pounds wheat bran
25 per cent high protein	300 pounds distillers' corn dried grains 200 pounds corn gluten feed
10 per cent very high protein	200 pounds soybean oil meal
	2,000 pounds

Total protein	19.9 per cent	Digestible protein	15.9 per cent
Total fat	4.4 per cent	Total digestible nutrients	74.6 per cent, or 1,492 pounds per ton
Crude fiber	8.2 per cent		

Use of High-Protein Supplemental Formula Feeds

Many dairymen prefer to use a high-protein commercial-mixed feed, such as a 24- or 30-per-cent mixture, with their farm-grown grains instead of buying the individual ingredients. The approximate proportion of home-grown grains that may be used with a 32 per cent supplement for different roughage combinations is given in table 2.

TABLE 2. PROPORTION OF HOME-GROWN GRAINS TO USE WITH 32 PER CENT PROTEIN SUPPLEMENT

Kind of roughage*	Home-grown grains	32 per cent supplement
	Pounds	*Pounds*
Non-legume hay and corn silage	800	1,200
Mixed hay, containing from 30 to 50 per cent legumes, and corn silage	1,200	800
Clover hay and corn silage	1,300	700
Alfalfa or soybean hay and corn silage	1,600	400

*If legume silage is fed in place of corn silage, the proportion of home-grown grains can be increased slightly.

Feeding the Individual Cow

The principles of feeding are the same for all cows, but in the actual feeding of individual cows the amounts of concentrate mixture fed must be varied according to the amounts of milk produced, to the butterfat test of the milk, and to the physical condition of each cow. A good rule to follow in feeding a cow for production is to give her each day such amounts and kinds of nutrients in palatable and suitable feeds as will permit her to produce the milk she is inherently capable of producing and at the same time to maintain good working physical condition and health.

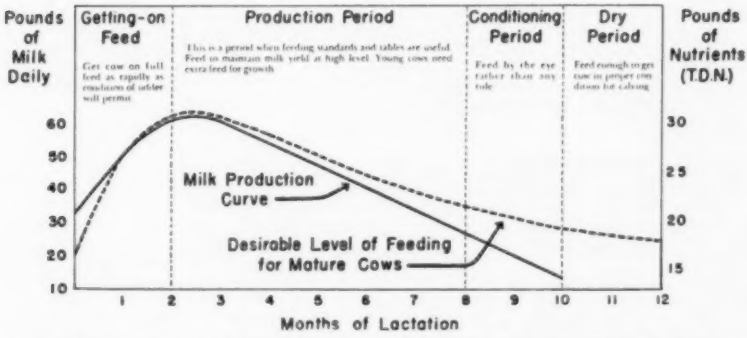

Figure 8. Cows should be fed throughout the year according to their milk yield, size, and body condition.

The importance of breeding high-producing ability into dairy cows cannot be over-emphasized. At the same time the importance of good feeding methods must be equally stressed. In the early part of a cow's lactation, a proper relationship between the milk she produces and the nutrients required for that production must be established and maintained throughout the lactation. If the feeder himself does not adjust his feeding methods to bring the nutrients of the ration up to the requirements of a cow, that cow herself will usually make an adjustment by dropping her milk production to the level of the feeding. The few cows that still maintain production when they are underfed do so only at the expense of their body condition. Such cows must have a long dry period of rest and good feeding before another freshening or have an "off-year" with production much lower than they are really capable of under proper feeding conditions.

Winter Feeding Milking Cows

Roughage

Roughage should be the main part of the winter ration because normally it furnishes the lowest cost nutrients and is best adapted to a cow's digestive system. If the hay and silages, the roughages commonly fed during winter, are of good quality, as much may be fed as the cows will eat.

Hay

On the basis of the roughage available on most dairy farms, cows should be fed all the hay they will clean up in at least two feedings—one feeding each after the morning and night milkings. If the hay is of poor quality and plenty is available, it is a good practice to put enough in the manger so the cows may pick it over and eat only the better and more nutritious parts. The remaining coarser parts should be removed and used for bedding. Better use of poor hay or other low-quality dry roughage may be made by sprinkling it with molasses diluted one-half with warm water. This is particularly true when no silage or succulent substitute for silage is fed. One quart of molasses weighs about 3 pounds, and from 1 to 3 pounds should be fed to each cow daily. Poor hay fed daily in this way with as much as 1 quart of molasses may be classed as fair hay. The quality of hay and the amounts must be known to feed cows the proper amount of other feeds.

Silages

Unless there is a scarcity of good hay, corn silage need not be fed heavily. Its succulence and palatability make a valuable supplement to hay, particularly to poor-quality hay. When plenty of good hay is available, from 20 to 30 pounds of corn silage is enough to get the advantages of its conditioning and stimulating effect.

In contrast to good legume or mixed hay, corn silage is low in protein and deficient in minerals. There is also a distinct advantage to feed no more silage than necessary to assure its availability up to the time cows can be turned out on pasture. Silage fed as a supplement to poor pasture is more valuable than when fed with good hay or hay-crop silage in excessive amounts during the winter.

Good silage made from legume or legume-grass crops may be substituted for all but 6 or 7 pounds of dry hay in the daily ration.

Figure 9. High-quality hay is a palatable and nutritious roughage and is particularly important during the barn-feeding season.

The amounts of grain mixture required by different cows producing the same amount and richness of milk depend somewhat upon their respective live weights. This is because the amounts of pasture or of hay and silage they can eat depends on their size.

Grain

Cows should be fed daily the kinds and amounts of concentrate feeds needed to supplement properly the roughage ration with enough additional protein and total digestible nutrients to meet their needs. Grain is largely a cash expense to most dairymen in New York and should be carefully fed according to the needs of each individual cow.

Winter grain-feeding table

The amount of grain needed daily by a cow depends on the amount and quality of the roughage she eats, on her liveweight and on the amount and butterfat test of the milk she gives. From tables 3, 4, and 5, a dairyman may find help in adjusting grain feeding to the roughage fed and to the milk produced so that he may feed individual cows efficiently and economically.

Estimates of the amounts of the various roughages fed and of the live weights of cows may not be accurate. They furnish, however, a much better basis for proper grain feeding than do any other methods except the actual weighing of the roughages and of the cow. Milk production and butterfat tests cannot be estimated. They must be determined by use of a milk scale and the Babcock test.

TABLE 3. CONVERSION FACTORS FOR CHANGING FEEDS INTO EQUIVALENT AMOUNTS OF GOOD HAY

Feeds	Remarks	Conversion factor
Grain mixtures	Bulky, weighing not more than 1 pound to a quart, 1,400 to 1,500 pounds of total digestible nutrients to a ton (grain mixtures cannot take the place of all roughage)	1.50
Beet pulp	Dry	1.33
Good hay	Alfalfa, clover, or mixed hay, cut reasonably early and put into mow without more than ordinary loss of leaves. Timothy and other hays cut in early bloom having high palatability	1.00
Fair hay	Alfalfa, clover, or mixed hay cut late, with loss of leaves due to maturity and method of handling. Timothy and other hays in late bloom	0.80
Poor hay	Legume or non-legume hays, coarse, stemmy, and unpalatable either because of very late cutting or of severe damage by adverse weather conditions	0.60
Cut or shredded corn stover	Cornstalks and leaves without ears, cut early and cured to preserve leaves. When fed uncut, about one-third is wasted and the value is less	0.60
Oat straw	Conversion factor used is estimated on value of total amount fed; other straws of considerably less value. Uneaten portion valuable for bedding	0.50
Corn silage	Peavine silage; brewer's grains, wet; fully soaked beet pulp; potatoes; apple pomace	0.33
Mangel beets	Rutabagas; cabbage	0.20
Molasses	Fed on poor roughage has equal value with grain; fed on good roughage or alone has a value three-fourths that of grain	

Amount of grain to feed

Recommendations for three different rates of roughage feeding are given in table 4, as shown by the first three columns. The second column, in bold-faced type, gives the figures for the most common rate of feeding roughage to dairy cows. This rate is to feed approximately 2 pounds of good hay daily for each 100 pounds of live weight, or the equivalent in other good roughage (for example, 1 pound of good hay and 3 pounds of silage).

When cows are fed *very liberally* on roughage of *excellent quality* and the allowance of grain is restricted to their needs, they will consume about 2.5 pounds of hay equivalent for each 100 pounds of live weight. The first column of figures is designed to fit these conditions.

The third column of figures is for use when cows are fed a scanty allowance of good roughage, or when they are fed as much poor roughage as they will consume without undue waste. This column is for use when cows consume only about the equivalent of 1.5 pounds of good hay daily for each 100 pounds of live weight.

In using the table, one first estimates approximately the number of pounds of hay equivalent the cows are actually consuming daily for each 100 pounds of live weight, after deducting the wastage. In making this estimate, the conversion factors in table 3 are used for converting the amounts of other roughages actually consumed into the equivalent amounts of good hay. (Good-quality legume hay or properly cured, early-cut grass hay is taken as the standard.)

To determine the pounds of hay equivalent fed for each 100 pounds of live weight, the hay equivalent of the roughage fed is determined from table 3, and

this weight is divided by the hundred pounds of live weight. Example: A 1200-pound cow is fed 10 pounds of good-quality mixed hay, 30 pounds of corn silage, and 7 pounds of corn stover daily. The hay equivalent of this roughage (table 3) is:

10 pounds of good hay	× 1.00 =	10.0 pounds
30 pounds of silage	× 0.33 =	9.9 pounds
7 pounds of corn stover	× 0.60 =	4.2 pounds
		24.1 pounds of good hay equivalent.

To get the pounds of good hay equivalent fed per 100 pounds of live weight: 24.1 pounds of hay equivalent divided by 12 (number of hundred pounds of live weight) = 2.0.

After the pounds of good hay equivalent eaten for each 100 pounds of live weight have been estimated, the dairyman may determine from table 4 the

TABLE 4. GRAIN-FEEDING TABLE FOR COWS NOT ON PASTURE*

Hay equivalent consumed per 100 pounds of live weight daily			Percentage of fat in milk						
2½ pounds Very liberal feeding of good roughage	2 pounds Usual rate of feeding good hay or good hay and silage	1½ pounds Feeding scanty amount of good roughage or feeding poor roughage	3.0	3.5	4.0	4.5	5.0	5.5	6.0
Milk produced daily, pounds			Total pounds of grain or concentrates to feed						
Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
17	10	..	...	...	...	1.9	2.2	3.1	3.5
19	12	..	...	...	1.6	2.8	3.2	4.2	4.6
21	14	..	1.5	2.0	2.4	3.8	4.2	5.3	5.7
23	16	9	2.3	2.9	3.3	4.7	5.2	6.3	6.8
25	18	11	3.0	3.6	4.2	5.6	6.2	7.4	8.0
27	20	13	3.7	4.4	5.0	6.5	7.2	8.4	9.1
29	22	15	4.5	5.2	5.9	7.5	8.2	9.5	10.2
31	24	17	5.2	6.0	6.8	8.4	9.2	10.5	11.3
33	26	19	6.0	6.8	7.6	9.3	10.2	11.6	12.5
35	28	21	6.7	7.6	8.5	10.3	11.2	12.7	13.6
37	30	23	7.4	8.4	9.3	11.2	12.2	13.7	14.7
39	32	25	8.2	9.2	10.2	12.1	13.2	14.8	15.8
41	34	27	8.9	10.0	11.1	13.1	14.2	15.8	17.0
43	36	29	9.6	10.8	11.9	14.0	15.1	16.9	18.1
45	38	31	10.4	11.6	12.8	14.9	16.1	18.0	19.2
47	40	33	11.1	12.4	13.7	15.9	17.1	19.0	20.3
49	42	35	11.8	13.2	14.5	16.8	18.1	20.1	21.5
51	44	37	12.6	14.0	15.4	17.7	19.1	21.1	22.6
53	46	39	13.3	14.8	16.3	18.7	20.1	22.2	23.7
55	48	41	14.1	15.6	17.1	19.6	21.1	23.3	
57	50	43	14.8	16.4	18.0	20.5	22.1		
59	52	45	15.5	17.2	18.9	21.4	23.1		
61	54	47	16.3	18.0	19.7	22.4			
63	56	49	17.0	18.8	20.6	23.3			
65	58	51	17.7	19.6	21.4	24.2			
67	60	53	18.5	20.4	22.3		Regardless of the amount of grain theoretically required by a cow, she should not be fed more than she can safely handle.		
69	62	55	19.2	21.2	23.2				
71	64	57	19.9	22.0	24.0				
73	66	59	20.7	22.8	24.9				
75	68	61	21.4	23.6	25.8				

*This table has been taken with the permission of the Morrison Publishing Company, Ithaca, New York, from *Feeds and Feeding*, 21st edition, by F. B. Morrison.

Figure 10. Good cows need to be fed grain according to their individual needs.

amount of grain mixture to feed daily to any particular cow. Using one of the first three columns in table 4 that most nearly fits the rate of roughage fed to his cow, he follows down that column to the amount of milk corresponding to that produced by his cow and then follows the horizontal row of figures to the vertical column having the percentage of fat nearest to that of the milk produced by the cow. The figure in this column shows the pounds of grain mixture to be fed daily to the cow.

To illustrate, assume that a cow yielding 36 pounds of milk containing 3.5-per-cent fat is being fed approximately 2 pounds of good hay equivalent for each 100 pounds of live weight. Following down the second column, which is for this rate of roughage feeding, until one comes to the figure *36,* and then horizontally to the right across the table to the column for 3.5 per cent fat, he finds the figure *10.8.* Therefore, this cow should be fed 10.8 pounds of a good grain mixture daily to meet her requirements.

When only 1½ pounds of hay equivalent is fed for each 100 pounds of live weight, barely enough nutrients are furnished for maintenance. Consequently, all the nutrients for milk produced must be furnished by grain. This accounts for the large amounts of grain called for in the table for use with light roughage feeding. If a dairyman has too little home-grown roughage to feed daily at least 2 pounds of hay equivalent for each 100 pounds of live weight, he can determine from the conversion factors given in table 3, and from the prices at which they are available, whether grain or hay can be purchased to the best advantage to make up the deficiency in home-grown roughage.

Good cows underfed on roughage and grain run down in body condition, and losses in production during the next lactation will result. This is particularly true of cows that are to freshen in the spring before they can get into condition on pasture.

High-producing cows going dry and producing only small amounts of milk deserve and require even more grain than is indicated in the table. Cows giving small amounts of milk in early lactation may need grain to maintain their live weight; but if this low production truly represents their ability, they should be disposed of as soon as possible. Heifers should be fed from 1½ to 2 pounds more grain than called for in the table if they are to maintain normal growth.

Protein content of grain mixtures

The pounds of grain needed to supply a cow with the proper amount of total digestible nutrients are given in table 4. The protein requirements must be met by the use of a grain mixture which has a protein content properly supplementing the protein supplied by the roughage. The total protein content of grain mixtures for use with various kinds of roughage is given in table 5.

TABLE 5. PROTEIN CONTENT OF GRAIN MIXTURES

Kind of roughage	Hay equivalent fed per 100 pounds of live weight		
	Pounds 2½	*Pounds* 2	*Pounds* 1½
	Total protein		
	Per cent	*Per cent*	*Per cent*
All non-legume	24	22	20
*Mixed hay and silage, or mixed hay and other non-legume dry roughage	20	18	16
Clover hay and silage, or clover hay and other non-legume dry roughage	16	14	12
Alfalfa or soybean hay and silage, or alfalfa or soybean hay and other non-legume dry roughage	12	12	12

*When the mixed, alfalfa, or soybean hay is less than one-half of the total hay equivalent fed, the protein content of the grain mixture should be increased 2 per cent.

Feeding Milking Cows on Pasture

The necessity for feeding cows to maintain daily milk production is the same on pasture as it is under barn-feeding conditions. Cows, however, are universally fed better during the winter than they are on pasture. Only pastures that have been improved and that are properly managed and grazed can furnish nutrients to cows for any considerable part of the pasture season in comparable amounts to those furnished by the roughages fed in winter. If the nutrient requirements of a cow weighing 1200 pounds and giving 30 pounds of 3.5-per-cent milk were met, she would need to eat 100 pounds of mixed pasture grasses daily. As a result of the unwarranted faith that most dairymen put in the productivity of the average permanent pastures, late-winter- and spring-freshening cows decline rapidly in daily milk production during July and August, and the total production for the year is greatly reduced.

Full advantage of pasturage should be taken and every effort made to increase and maintain milk yields through the use of improved permanent pastures, seeded pastures, oats and Sudan grass, and of good grazing practices. When pas-

Figure 11. Alfalfa-grass meadow aftermath is an excellent summer-pasture feed.

Figure 12. Sudan grass grown under favorable conditions provides an abundance of pasture feed in the latter part of July and in August.

Figure 13. Hay fed as a supplement to inadequate pastures may best be fed in movable hay racks.

tures are inadequate to meet the full nutritional needs of cows, good hay and corn- or hay-crop silage should be fed as supplemental feeds in addition to enough of a grain mixture to maintain normal milk production and to keep milking cows in good physical condition.

Grain-feeding Table[2]

Recommendations for cows that are on excellent pasture, on good pasture, and on fair pasture are given in table 6. The first column of figures is for use when the cows are on pasture that provides an abundance of very palatable, nutritious forage. Such forage is furnished by usual pasture grass only during the flush of growth in late spring and early summer. Usually, only pasture that is liberally fertilized and also well managed will furnish such pasturage later in the season.

The third column of figures is for use when the cows are on fair pasture, but not on pasture that is distinctly poor. On poor pasture, cows will need fully as large an allowance of grain mixture as when fed roughage of only fair quality during the winter.

To use the table, one must first decide whether the pasture is excellent, good, or fair. Then the procedure is as follows:

Assuming that the herd is on good pasture, and that one wishes to find how much grain mixture should be fed to a cow yielding 35 pounds of milk containing 3.5 per cent fat, he follows down the second column of figures, which is for cows on good pasture, until he reaches the figure *35*, then horizontally to the right across the table until he reaches the column for milk containing *3.5* per cent, where he finds the figure *7.6*. This shows that this cow should be fed 7.6 pounds of suitable grain mixture daily to meet her requirements.

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[2]This discussion and table 6 have been taken with the permission of the Morrison Publishing Company, Ithaca, New York, from *Feeds and Feeding*, 21st edition, by F. B. Morrison.

TABLE 6. GRAIN-FEEDING TABLE FOR COWS ON PASTURE

Quality of pasture			Percentage of fat in milk						
Excellent	Good	Fair	3.0	3.5	4.0	4.5	5.0	5.5	6.0
Milk produced daily			Total pounds of grain or concentrates to feed						
Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
22	13	..	...	...	...	...	...	...	1.2
24	15	..	...	...	...	...	1.2	2.0	2.3
26	17	..	...	...	...	1.9	2.2	3.1	3.5
28	19	10	...	...	1.6	2.8	3.2	4.2	4.6
30	21	12	1.5	2.0	2.4	3.8	4.2	5.3	5.7
32	23	14	2.3	2.8	3.3	4.7	5.2	6.3	6.8
34	25	16	3.0	3.6	4.2	5.6	6.2	7.4	8.0
36	27	18	3.7	4.4	5.0	6.5	7.2	8.4	9.1
38	29	20	4.5	5.2	5.9	7.5	8.2	9.5	10.2
40	31	22	5.2	6.0	6.8	8.4	9.2	10.5	11.3
42	33	24	6.0	6.8	7.6	9.3	10.2	11.6	12.5
44	35	26	6.7	7.6	8.5	10.3	11.2	12.7	13.6
46	37	28	7.4	8.4	9.3	11.2	12.2	13.7	14.7
48	39	30	8.2	9.2	10.2	12.1	13.2	14.8	15.8
50	41	32	8.9	10.0	11.1	13.1	14.2	15.8	17.0
52	43	34	9.6	10.8	11.9	14.0	15.1	16.9	18.1
54	45	36	10.4	11.6	12.8	14.9	16.1	18.0	19.2
56	47	38	11.1	12.4	13.7	15.9	17.1	19.0	20.3
58	49	40	11.8	13.2	14.5	16.8	18.1	20.1	21.5
60	51	42	12.6	14.0	15.4	17.7	19.1	21.1	22.6
62	53	44	13.3	14.8	16.3	18.7	20.1	22.2	23.7
64	55	46	14.1	15.6	17.1	19.6	21.1	23.3	Regard-
66	57	48	14.8	16.4	18.0	20.5	22.1	less of the	
68	59	50	15.5	17.2	18.9	21.4	amount of grain		
70	61	52	16.3	18.0	19.7	22.4	theoretically required		
72	63	54	17.0	18.8	20.6	23.3	by a cow, she should not be fed		
74	65	56	17.7	19.6	21.4		more than she can safely handle.		

The second column of figures is for use when the cows have a plentiful supply of good pasturage, but when the pasture can hardly be called excellent. On such pasture the cows must be able to get somewhat more feed from the pasture than they do from a full feed of good hay and average silage in winter.

Protein content of grain mixture

Young pasture grass contains fully as much protein, on the dry basis, as does alfalfa hay. The best pasturage, containing considerable white clover or other legumes, is even richer than alfalfa hay in protein. Therefore, cows on good pasture do not need a grain mixture rich in protein. Merely a mixture of farm grains or a concentrate or a grain mixture containing 12 per cent of protein furnishes plenty of protein for cows on excellent pasture, except for the very heavy producers. On good pasture, a protein content of 14 to 16 per cent is enough.

Unless the grass is kept growing actively by proper fertilization and good pasture management, it will be considerably lower in protein content, on the dry basis, during midsummer. Then a grain mixture that contains more protein is needed. Unless the pasture is decidedly poor, however, it will not be necessary to have more than 16 to 18 per cent protein in the grain mixture.

Conditioning Cows during Dry Period

It is not an unusual thing for good cows to use material from their own bodies in their milk production. Body tissue and fat and minerals from the bones are

so used. During the latter stages of lactation and during the dry period such cows replace these materials, provided the period is long enough and proper kinds and amounts of feed are supplied.

The importance of properly conditioning cows when they are dry cannot be over-emphasized. The physical fitness of a cow at freshening time determines in a large measure the extent of her production. All cows should be in a high state of health and carry a surplus of fat when they freshen. This surplus of fat is available for immediate use when cows come into milk and makes it possible for production to increase normally on small amounts of grain mixture at a time when the condition of the cow makes heavier grain feeding undesirable. It also makes it simpler to determine the amount of grain that should be fed, because it is possible to increase grain as the daily milk yield increases.

It should be kept in mind, however, that a cow may be in good flesh without having built up the mineral reserves in her body. Only a sufficiently long dry period and a plentiful supply of feeds containing minerals, or the use of calcium and phosphorus supplements, will accomplish a proper storage of minerals in the cow's body.

The length of time a cow should go dry depends on her condition at the close of her milking period, and on the ease with which she responds to conditioning. Very few cows need less than a six weeks' dry period and most need eight weeks. The important thing in feeding during the dry period is to supply such grain or grain mixtures in addition to hay, silage, or pasture as are necessary to produce the desired results. Usually it is not necessary to feed heavily of grain nor to feed a ration high in protein to accomplish practical results in conditioning. Feeding for this purpose must be guided by the eye rather than by rule. If the cows are decidedly thin and are to freshen in six or eight weeks, from 6 to 8 pounds or more of a low-protein–grain mixture or fitting ration with a high percentage of total digestible nutrients should be fed daily.

In getting cows in good condition before calving, good hay, preferably legume, and silage or abundant pasture should be largely depended on. These are the most economical feeds and the nutritive elements supplied in these forages are especially important in building the cow's reserves.

The same concentrate mixture being fed to the milking herd may be used for dry cows. If a fitting ration is needed, a good one may be made up of 300 pounds of ground corn, ground barley, or hominy feed, 300 pounds of ground oats, 300 pounds of wheat bran, and 100 pounds of soybean oil meal or linseed meal. In addition, cows should have access to one of the mineral mixtures given on page 11.

Many special dry-cow and freshening formula feeds are on the market. They are satisfactory for those dairymen who wish to use them.

For a week or two before calving, it is often recommended that cows be fed concentrate mixtures that are bulky and laxative to prevent udder congestion. Often, mixtures containing equal parts of ground oats and wheat bran or these feeds in combination with linseed meal are used. Recently, many feed manufacturers have been putting out special freshening rations that are bulky and contain large amounts of ground hay and molasses. Experiments, however, do not show any differences in udder congestion or other effects from feeding any of these special mixtures if the ration previously fed has been laxative enough to prevent constipation. It is normal for good cows to develop some congestion in their

udders just prior to calving and, contrary to common opinion, the ration seems to have little effect on this condition.

At least one Experiment Station uses a different method of feeding dry cows. During the latter months of gestation, the cows are fed liberal amounts of concentrates so they are in good physical condition at the time they are dried off. They are then fed only liberal amounts of good roughage during the dry period, with no concentrates. The concentrates that are normally fed to dry cows, therefore, are given during the lactation period. It is reported that fewer difficulties at calving are encountered and that there is less inflammation in the udder. Such a method probably is satisfactory where cows are fed liberal amounts of high-quality roughages.

Cows that are due to calve should be given some exercise each day.

Drying-off Cows

Various methods are used to dry off cows. Probably the best and most rapid procedure is to stop milking abruptly. The udder can be washed carefully and the teats sealed with collodion to prevent the entrance of bacteria. If the udder should fill with so much milk that undue congestion appears, then the udder should be milked out completely, and only milked again as it becomes necessary.

Those cows with quarters infected with mastitis may present more of a problem. Then, the dairyman must use any procedure that is best for the particular cow.

Cows that are persistent and are milking 30 or 40 pounds daily may present problems at drying off time. It may be necessary to change to a low-protein concentrate mixture for one or two months before the cow is due to go dry. Also, when it is time to dry up the cow, it may be necessary to withhold all feed, except hay and water, for a day or two. The drying-off process needs to be as short as possible to prevent cows from losing flesh.

Feeding after Calving

To obtain a large yearly production from a cow, it is important that she be fed properly all during the year and especially just after calving. Each cow should be fed carefully to prevent digestive disturbances or udder troubles.

Following calving the amount of feed the first day should be limited. The cow may be given what hay and silage she cares for and only a small allowance of concentrates. The same concentrate mixtures used before calving or during the dry period may be fed. If water bowls are not in the stall, the cow should be given some lukewarm water the first day.

After the first day, the amount of concentrates may be increased gradually. No definite rule can be followed to get a cow on feed. Each cow must be handled differently. The amount of grain and other feeds should be increased as the cow increases her production and maintains a good appetite for handling feed. It is highly important to get cows on full feed as soon as possible after calving, especially in those herds where troubles from ketosis, or acetonemia, are being encountered. Care, of course, should be taken not to throw cows "off-feed" by forcing them unduly. It may take three or four weeks to get some high producers on full feed, while lower producers may be fed their full allowance somewhat earlier.

If an udder becomes swollen or badly congested, it may be necessary to reduce the amounts of grain mixture being fed. As the trouble clears up, the grain should be gradually increased again.

All dairymen know that their best cows may have milk fever during the first few days after calving. By checking the secretion of milk, the tendency towards milk fever is reduced. Therefore, with high-producing cows that dairymen know may have a tendency to develop milk fever, only enough milk should be milked out the first day to supply the calf.

Feeding Dairy Bulls

A young dairy bull should always be fed so that he will make good growth and reach normal size. Essentially the same methods of feeding that are used for dairy heifers can be used for the young bulls.[2] They should be kept in a thrifty, vigorous, growthy condition rather than allowed to become fat.

The key to success in growing young stock is high-quality hay. Therefore, by giving the young bull plenty of early cut leafy hay that is rich in calcium and vitamins A and D, he will grow rapidly and develop lots of size. The young bull should be given enough grain feed to keep him in good condition. Care should be taken to see that plenty of minerals are provided in the feed and also plenty of vitamins, particularly vitamin D. If the calves are not in the sunshine and good-quality sun-cured hay is not available, the addition of a vitamin-A and vitmain-D concentrate may be advisable.

After the bull calves have been separated from the heifers at five or six months of age, they should be fed somewhat larger amounts of feed, especially concentrates, than those fed a heifer. This is because bulls grow more rapidly than heifers and need more feed. A well-fed and well-grown bull will be ready for service at ten to twelve months of age but should not be given heavy service until about two years of age.

A bull in service should be kept in a thrifty condition but not allowed to become fat. The basis of the ration should be good-quality hay, preferably legume or mixed legume and grass hay. The bull should, however, not be allowed to eat excessive amounts of hay which would make him too large through the middle. If the bull becomes too paunchy, he may be slow and sluggish in service.

Some breeders do not like to give silage to a bull and, if the quality of hay is good, there is little need for succulence in the bull ration. There is little sound basis, however, for the prejudice against silage for bulls, and it may be used satisfactorily in amounts of 20 to 30 pounds a day.

The grain mixture for bulls need not be so high in protein as for milking cows. A mixture that is satisfactory for dry cows or growing heifers is generally satisfactory for bulls, the amount of protein depending on the kind of roughage. With mixed legume-grass hay, concentrate mixtures containing 12 per cent of protein give as good results as those furnishing higher amounts of protein.

Many breeders prefer ground oats for the basis of the grain mixture, and during the heavy breeding season use a mixture of equal parts by weight of ground oats, ground corn, wheat bran, and linseed oil meal. A satisfactory mixture for service bulls is also the following:

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[2]Complete feeding information is given in Cornell Extension Bulletin 761, *Raising Dairy Calves and Heifers*, by K. L. Turk and J. D. Burke.

300 pounds ground corn } or 600 pounds oats and barley
300 pounds ground oats }
300 pounds wheat bran
100 pounds linseed meal, or soybean oil meal

A mineral mixture of equal parts of salt and steamed bonemeal should be kept where the bull has free access to it at all times.

If good hay is being fed, from 4 to 6 pounds of one of the grain mixtures should be enough to keep the bull in the desired condition. This will vary, of course, with the size of the bull and the amount of service, and the exact amounts of feed must be determined by the feeder.

Mature bulls in heavy service need from 8 to 11 per cent more total digestible nutrients to maintain their weight than the amounts shown in the higher recommendations of the Morrison Feeding Standards for the maintenance of dairy cows (table 8, page 47).

In spite of some claims to the contrary, there is no benefit from the addition of wheat germ oil as a vitamin-E supplement or fish liver oil as a vitamin-A supplement to the ration of breeding bulls.

Some General Considerations in Feeding

Effect of Feeds on Fat Content of Milk

One of the questions frequently asked concerns the effects of certain feeds on the percentage of fat in milk. The butterfat test in milk varies greatly. It is well known that as the milk production of an individual cow declines, there is an increase in butterfat test. Cows test higher in winter than in summer; and tests vary from milking to milking, depending on the interval between milkings and the completeness of milking. The cow in excellent flesh at the time of freshening will test higher for several weeks than she will when freshening in a thin condition. Such increases are more notable with cows of the lower testing breeds. Many dairymen believe that cows test higher when they are kept in good condition throughout the lactation period.

Changes in the ration may often cause decided temporary changes in the fat test. In changing from any poor system of feeding to one that provides cows amply according to their requirements, the odds are in favor of the butterfat test increasing.

Many experiments have been conducted with various feeds and other products to determine whether the fat percentage in milk can be directly influenced by the ration. In general, these experiments show that a temporary increase in fat percentage may result from adding to the ration large amounts of certain feeds high in fat or certain oils. For example, large quantities of ground soybeans in the concentrate mixture have been shown to raise the fat percentage; but the amounts of ground soybeans ordinarily needed to balance the ration in protein would probably exert no appreciable influence on fat percentage.

In usual feeding practice, it is doubtful whether the sale of any feed or feed mixture can be justified on the basis that it will directly increase the fat content of milk.

Cod-liver oil fed to milking cows lowers the fat percentage in milk. This oil should not be fed to lactating cows.

Thyroprotein in Dairy Feeding

Thyroprotein has recently been made available for use in dairy feeds. This product is made by treating casein, the protein from milk, with iodine. It has thyroxin-like properties. Thyroxin is a hormone produced in the animal body which helps to regulate many of the body functions, including milk production.

Results of experiments have been rather generally agreed that the addition of thyroprotein to a dairy ration increases milk yield and fat percentage. Increases have varied considerably but they have averaged about 20 per cent for milk yield and about 30 per cent for fat yield. Where these increases in milk yields have been obtained, weight losses have been heavy. To prevent weight losses, it is necessary to increase by approximately 25 per cent the rate of grain feeding over the amounts called for in feeding standards or feeding tables. It is also known that when thyroprotein is fed, the heart rate and respiration rate are speeded up considerably. Also, there is increased nervousness of the cows.

Few long-time thyroprotein feeding experiments have been reported. Until results have shown no ill effects from feeding thyroprotein over a period of years, it should be used cautiously.

Taking all information into consideration the only possible place for thyroprotein feeding is in a few strictly commercial areas where breeding programs are not followed and where cows are commonly disposed of after milk yield reaches a low point. Even then it becomes a question of economy. The cost of the thyroprotein plus the extra feed needed must be more than offset by increased milk yields. In these few areas where thyroprotein might be fed, it should not be given to cows during the flush of lactation following calving, after about the seventh month of pregnancy, or to cows of low productivity.

The use of thyroprotein and similar substances is prohibited for cows on official test under any of the plans of the Breed Registry Associations.

Regularity in Feeding

The dairy cow is a creature of habit and seems to do better when all feeding and management procedures are carried out regularly. Care should be taken to avoid daily irregularities in feeding.

The most common system of feeding, and one that gives good results, is to feed concentrates just before or at the time of milking. Silage is fed right after milking and this is followed by the feeding of hay. If cows are milked three times daily, then concentrates are fed at each milking.

Some dairymen prefer to feed hay several times a day during the winter months. Such a system uses more labor but may stimulate cows to eat more hay.

TABLE 7. AVERAGE COMPOSITION AND DIGESTIBLE NUTRIENTS OF COMMON FEEDS*

Feed	Total dry matter	Digestible protein	Total digestible nutrients	Average total composition			
				Protein	Fat	Fiber	Nitrogen-free extract
Dry roughages	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Alfalfa hay, all analyses	90.5	10.5	50.3	14.8	2.0	28.9	36.6
Alfalfa hay, leafy (25–28% fiber)	90.5	11.7	51.5	15.8	2.2	27.4	36.6
Alfalfa hay, good (28–31% fiber)	90.5	10.3	50.4	14.3	1.8	29.7	36.5
Alfalfa hay, fair (31–34% fiber)	90.5	9.7	49.8	13.5	1.7	31.8	36.0
Alfalfa hay, stemmy (over 34% fiber)	90.5	8.1	46.2	12.1	1.4	36.0	33.4
Bean pods, field, dry	91.8	3.5	50.3	7.1	1.0	34.8	45.0
Birdsfoot trefoil hay	90.5	9.5	51.1	13.8	2.1	27.5	41.2
Brome grass hay, all analyses	88.1	5.0	48.9	9.9	2.1	28.4	39.5
Buckwheat straw	88.6	1.2	37.5	4.3	1.0	36.2	38.8
Clover hay, red, all analyses	88.1	7.1	52.2	11.8	2.6	27.2	40.1
Clover and mixed grass hay (high in clover)	89.7	5.5	52.2	9.6	2.7	28.8	42.4
Clover and timothy hay, 30 to 50% of clover	88.1	4.8	51.2	8.6	2.2	30.3	41.2
Corn fodder, well eared, very dry	91.1	3.8	58.8	7.8	2.2	27.1	47.6
Corn stover, ears removed, very dry	90.6	2.1	51.9	5.9	1.6	30.8	46.5
Grass hay, mixed, Eastern States, good quality	89.0	3.5	51.7	7.0	2.5	30.9	43.1
Millet hay, Japanese	86.8	5.1	47.3	8.3	1.6	27.7	40.8
Mixed hay, good, less than 30% legumes	88.0	4.4	49.8	8.3	1.8	30.7	41.8
Oat hay	88.1	4.9	47.3	8.2	2.7	28.1	42.2
Oat straw	89.7	0.7	44.7	4.1	2.2	36.1	41.0
Soybean hay, good, all analyses	88.0	9.6	49.0	14.4	3.3	27.5	35.8
Sudan grass hay, all analyses	89.3	4.3	48.5	8.8	1.6	27.9	42.9
Timothy hay, all analyses	89.0	2.9	48.9	6.5	2.4	30.2	45.0
Timothy hay, early bloom	89.0	4.1	50.8	7.5	2.4	30.0	44.4
Timothy hay, late bloom to early seed	89.0	2.6	44.2	6.1	2.7	29.7	45.5
Soybean seed	90.0	33.7	87.6	37.9	18.0	5.0	24.5
Soybean oil meal, expeller or hydraulic process, all analyses	90.9	37.2	78.4	44.3	5.3	5.7	29.6
Soybean oil meal, solvent process	90.6	42.4	78.5	46.1	1.0	5.9	31.8
Wheat, average of all types	89.5	11.1	80.0	13.2	1.9	2.6	69.9
Wheat bran, all analyses	90.1	13.7	67.2	16.9	4.6	9.6	52.9
Wheat mixed feed, all analyses	89.7	14.3	70.6	17.2	4.5	7.2	56.1
Wheat standard middlings, all analyses	89.6	15.0	77.2	18.1	4.8	6.5	55.8
Yeast, brewers', dried	93.8	42.4	70.5	49.3	1.0	3.7	31.9
Yeast, irradiated, dried	93.9	41.9	70.2	48.7	1.1	5.5	32.2
Green roughage, roots							
Alfalfa green, all analyses	25.3	3.4	14.7	4.5	0.9	7.2	10.4
Alfalfa and timothy pasture, half alfalfa	21.7	3.4	14.1	4.3	0.8	4.5	9.7
Bluegrass, Kentucky, pasture	30.2	3.9	19.2	5.5	1.2	7.6	13.4
Cabbage, entire	9.4	1.9	8.1	2.2	0.3	1.0	5.0
Carrots, roots	11.9	0.9	10.3	1.2	0.2	1.1	8.2
Clover, ladino, and grass pasture, mostly grass	20.0	2.0	13.1	2.7	0.6	5.0	9.6
Corn stover, green, field corn (ears removed)	22.7	0.5	13.0	1.3	0.4	6.0	13.6
Mangels, roots	9.2	0.9	7.0	1.3	0.1	0.8	6.0
Oat pasture, before heading	14.0	2.4	9.1	3.2	0.6	2.8	5.4
Orchard-grass pasture	23.9	2.2	12.1	4.3	1.1	5.5	10.0
Pasture grasses and legumes, mixed, from well-grazed, fertile pasture, Northern States	22.0	3.7	14.9	5.0	0.9	4.8	9.4
Potatoes, tubers	21.2	1.3	17.9	2.2	0.1	0.4	17.4
Sudan grass, pasture stage	21.6	2.4	14.3	3.3	0.6	5.6	10.2
Timothy, pasture stage	23.9	3.5	15.4	4.7	0.9	4.6	11.1
Silages							
Alfalfa, not wilted, no preservative	25.0	2.7	13.7	4.2	0.9	8.1	9.5
Alfalfa, wilted before being ensiled	36.0	4.1	21.3	6.0	1.4	11.7	13.7
Alfalfa-molasses, not wilted	26.8	2.7	15.4	4.1	0.9	8.2	11.2
Corn, dent, well-matured, all analyses	27.4	1.2	18.1	2.2	0.8	6.7	16.1
Corn and soybeans, well matured, 30% or more soybeans	28.3	2.0	19.7	3.2	1.2	7.3	14.2
Grass silage, small proportion legumes, not wilted	26.5	1.6	16.2	2.9	1.0	9.2	10.9

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(Table 7 continued on page 46.)

TABLE 7. *Concluded*

Feed	Total dry matter	Digestible protein	Total digestible nutrients	Average total composition			
				Protein	Fat	Fiber	Nitrogen-free extract
Silages							
Peavine, from canneries	24.5	1.9	14.0	3.2	0.8	7.3	11.0
Soybean, not wilted	24.8	2.9	14.6	4.2	0.7	7.3	10.0
Sunflower	22.6	1.0	12.2	2.1	1.0	7.0	10.2
Concentrates							
Babassu oil meal	92.8	20.8	81.6	24.2	6.8	12.0	44.6
Barley, common	89.4	10.0	77.7	12.7	1.9	5.4	66.6
Beans, field, or navy	90.0	20.2	78.7	22.9	1.4	4.2	57.3
Beet pulp, dried	90.1	4.3	67.8	9.2	0.5	19.8	57.2
Brewers' grains, dried, 25% protein or over	92.9	22.1	67.1	27.6	6.5	14.3	40.9
Brewers' grains, dried, below 25% protein	92.3	16.8	61.8	23.4	6.4	16.1	42.5
Brewers' grains, wet	23.7	4.2	16.1	5.7	1.6	3.6	11.8
Buckwheat, ordinary varieties	88.0	7.4	62.2	10.3	2.3	10.7	62.8
Buckwheat, Tartary	88.1	7.3	61.8	10.1	2.4	12.7	60.9
Buckwheat feed, good grade	89.3	11.7	52.5	18.5	4.9	18.2	43.5
Buckwheat middlings	88.7	25.8	75.7	29.7	7.3	7.4	39.4
Citrus pulp, dried	90.1	2.5	74.4	5.9	3.1	11.5	62.7
Coconut oil meal, hydr. or exp. process	93.2	18.1	77.7	21.3	6.7	10.7	48.3
Coconut oil meal, solvent process	91.1	18.2	68.6	21.4	2.4	13.3	47.4
Corn, dent (Grade No. 2)	85.0	6.6	80.1	8.6	3.9	2.0	69.3
Corn ears (corn-and-cob meal)	86.1	5.3	73.2	7.3	3.2	8.0	66.3
Corn feed meal	88.6	7.5	83.1	9.8	4.7	2.9	69.2
Corn gluten feed, 23% protein guarantee	91.4	21.3	76.3	24.8	2.6	7.8	49.8
Cottonseed meal, 43% protein grade, not including Texas analyses	92.7	36.4	75.8	43.9	7.1	9.0	26.3
Cottonseed meal, solvent process	90.8	35.1	63.1	44.4	2.6	12.7	24.3
Distillers' dried corn grains without solubles	92.9	20.7	82.4	28.3	8.8	11.4	41.9
Distillers' dried corn grains, with solubles	93.1	21.0	80.9	28.8	8.9	9.0	41.7
Distillers' dried corn grains, solvent extracted	93.7	24.4	71.2	33.4	1.4	8.6	46.4
Distillers' dried rye grains	93.9	11.1	60.8	18.5	6.4	15.6	51.0
Distillers' solubles, dried, corn	93.0	19.5	77.1	26.7	7.9	2.6	48.4
Hominy feed, 5% fat or more	90.4	8.0	84.5	11.2	6.9	5.2	64.2
Hominy feed, low in fat	89.7	7.5	81.4	10.6	4.3	5.0	67.0
Linseed meal, old process, all analyses	91.0	30.8	77.2	35.4	5.8	8.2	36.0
Linseed meal, solvent process, older analyses	90.4	31.0	72.3	36.9	2.9	8.7	36.3
Molasses, cane, or blackstrap	74.0	0	54.0	2.9	0	0	62.1
Oats, not including Pacific Coast States	90.2	9.4	70.1	12.0	4.6	11.0	58.6
Oats, light weight	91.3	8.5	60.1	12.3	4.7	15.4	54.4
Palm-kernel oil meal	91.4	15.4	76.5	19.2	6.7	11.9	49.7
Peanut oil meal, old process, all analyses	93.0	39.6	82.4	43.5	7.6	13.3	23.4
Peanut oil meal, solvent process	91.6	46.9	76.5	51.5	1.4	5.7	27.2
Rye grain	89.5	10.0	76.1	12.6	1.7	2.4	70.9
Rye middlings	90.2	12.6	72.0	16.6	3.4	5.2	61.2
Sesame oil meal	93.7	38.9	70.9	42.8	9.4	6.2	22.8
Skimmilk, dried	94.2	31.2	80.7	34.7	1.2	0.2	50.3

TABLE 8. MORRISON FEEDING STANDARDS FOR DAIRY COWS, SHOWING DAILY NUTRITIONAL ALLOWANCES*

Need	Digestible protein (lower amounts minimum advised, higher amounts advised under usual conditions)	Total digestible nutrients (lower amounts minimum advised, higher amounts advised under usual conditions)	Calcium	Phosphorus	Carotene
For maintenance, per head daily	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Milligrams*
700-pound cow	0.44–0.48	5.1–5.8	0.015	0.015	42
800-pound cow	0.49–0.54	5.8–6.5	0.018	0.018	48
900-pound cow	0.55–0.59	6.4–7.2	0.020	0.020	54
1000-pound cow	0.60–0.65	7.0–7.9	0.022	0.022	60
1100-pound cow	0.65–0.71	7.6–8.6	0.024	0.024	66
1200-pound cow	0.70–0.76	8.2–9.3	0.026	0.026	72
1300-pound cow	0.75–0.82	8.8–10.0	0.029	0.029	78
1400-pound cow	0.80–0.87	9.4–10.6	0.031	0.031	84
1500-pound cow	0.85–0.92	10.0–11.3	0.033	0.033	90
1600-pound cow	0.90–0.98	10.5–11.9	0.035	0.035	96
1700-pound cow	0.95–1.03	11.1–12.6	0.037	0.037	102
1800-pound cow	1.00–1.08	11.7–13.2	0.040	0.040	108
For milk production, per pound of milk (to be added to allowance for maintenance)					
3.0 per cent milk	0.036–0.043	0.26–0.28	0.0022	0.0017	..
3.5 per cent milk	0.038–0.046	0.28–0.30	0.0022	0.0017	..
4.0 per cent milk	0.041–0.049	0.31–0.32	0.0022	0.0017	..
4.5 per cent milk	0.044–0.052	0.33–0.35	0.0022	0.0017	..
5.0 per cent milk	0.046–0.056	0.35–0.37	0.0022	0.0017	..
5.5 per cent milk	0.049–0.059	0.38–0.40	0.0022	0.0017	..
6.0 per cent milk	0.052–0.062	0.40–0.42	0.0022	0.0017	..
6.5 per cent milk	0.054–0.065	0.42–0.45	0.0022	0.0017	..
Additional allowance for last 2 to 3 months of pregnancy (to be added to allowance for maintenance and milk production)					
Small cow	0.50–0.55	5.0–5.5	0.023	0.014	24
1000-pound cow	0.55–0.60	5.5–6.0	0.029	0.018	30
Large cow	0.65–0.70	6.5–7.0	0.034	0.021	36

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